Article:

Gravelle, Hugh Stanley Emrys orcid.org/0000-0002-7753-4233, Liu, Dan orcid.org/0000-0002-1891-9352, Propper, Carol et al. (1 more author) (2019) Spatial competition and quality : Evidence from the English family doctor market. Journal of Health Economics. 102249. ISSN 0167-6296

https://doi.org/10.1016/j.jhealeco.2019.102249

To appear in *Journal of Health Economics*

Spatial competition and quality: Evidence from the English family doctor market

Hugh Gravelle[a] **Dan Liu**[a] **Carol Propper**[b] **Rita Santos**[a]

9 October 2019

Abstract

We examine whether family doctor firms in England respond to local competition by increasing their quality. We measure quality in terms of clinical performance and patient-reported satisfaction to capture its multi-dimensional nature. We use a panel covering 8 years for over 8000 English general practices. We measure competition as the number of rival doctors within a small distance and control for a large number of potential confounders. We find that increases in local competition are associated with increases in patient satisfaction and to a lesser extent in clinical quality. However, the magnitude of the effect is small.

Word count: 100

JEL Nos: I11, I18

Keywords: Quality; healthcare; choice; competition; family physicians

Acknowledgements. The paper is based on independent research commissioned and partly funded by the NIHR Policy Research Programme Ref 103/0001). RS was part funded by an NIHR Doctoral Fellowship (DRF 2014-07-055. CP was funded by the Economic and Social Research Council under grant ES/J023108/1. We thank David Byrne, participants at seminars in York, Melbourne and the HESG conference, and three referees and the editor for their comments. The views expressed are those of the authors and not necessarily those of the NIHR, the Department of Health and Social Care, or the ESRC.

---

[a] Economics of Health and Social Care Research Centre, Centre for Health Economics, University of York.

[b] Imperial College London, CMPO University of Bristol, CEPR and IFS.

1 Introduction

Quality competition is pervasive and important. Quality is a key component of service products such as, transport, telecoms, banking, education and healthcare. Competition on quality is a central component of industrial organisation (product differentiation, bundling, price discrimination). But the relationship between quality and competition is hard to study empirically. Quality is multi-dimensional and often difficult to measure, product prices and quality are typically set together, and market structure and quality are jointly determined. Empirical studies on quality competition are relatively scarce.[1]

One area where an understanding of the empirical relationship between quality and market structure is central is healthcare. Healthcare accounts for over 10 percent of the economy of most developed countries. The quality of care can have large, and long-lasting, effects on the health of the consumer. Injecting greater competition into heavily regulated healthcare markets is a popular reform model in many jurisdictions (Gaynor et al. 2016; Glied and Altman, 2017; OECD, 2012; Siciliani et al., 2017). But this takes place against the backdrop of a long-term trend of provider consolidation in healthcare markets (Gaynor and Town, 2012; Fulton 2017). Understanding the relationship between quality and market structure in healthcare is therefore important.

Theoretically, the relationship between competition and quality is ambiguous (Gaynor and Town, 2012), even in markets where price is regulated (Brekke et al., 2011; 2014) Empirically, the bulk of the literature on the relationship between competition and quality in the hospital sector points towards a positive relationship where price is regulated (Gaynor and Town, 2012).[2] In this paper we examine the relationship between quality of care and market structure in local physician markets. This has been much less researched and the empirical evidence is scarce (Gaynor and Town, 2012). Yet, as in the hospital sector, physician markets are becoming more concentrated and much of this is below the radar of regulatory authorities (Capps et al., 2017). If effort is to be spent promoting competition there is a need to know whether this will increase quality.

---

[1] Examples include the media (Berry and Waldfogel, 2001; Fan, 2016), airlines (Mazzeo, 2003), supermarkets (Matsa, 2010).
[2] For recent evidence from the UK see Cooper et al. (2011), Gaynor et al. (2013), and Bloom et al. (2015). Moscelli et al. (2018) find more mixed results.

We study family physician firms (known as general practices) in the English National Health Service (NHS). General practices provide primary care (healthcare outside the hospital or nursing home setting) and act as gatekeepers to almost all other services provided by the NHS. They are small businesses, typically owned and run by a partnership of 4-5 general practitioners (GPs) who employ nursing and other staff. Almost all practices operate in a single small local market. In common with most European countries, care is free at point of use. Payments to practices are determined nationally and the institutional set-up gives practices an incentive to compete for patients. Patients can only register with one practice and around 75% of practice revenue comes from the number of patients registered with the practice. As patients face zero prices, any positive effect from competition has to come from changes in quality. Figure 1 shows the market structure for England (as measured by the Herfindhal-Hirschman Index (HHI) of concentration of practice registrations) across the small areas from which GP practices draw their potential patients. The figure shows considerable variation in market concentration. Some markets are unconcentrated, others are highly concentrated. Markets in urban areas are, as expected, much less concentrated than those in rural areas but even within urban and rural areas there is considerable variation. In this setting, patient choice of practice has been shown to be responsive to quality (Santos et al., 2017). Thus, the pre-requisites for competition between providers to improve quality exists: the question is whether it does.

To answer this, we study the universe of all GP practices (over 8000) in England between 2005 and 2012.[3] We use six practice-specific measures of quality, some relating to the quality of medical care as judged by national clinical standards and others relating to patient reported satisfaction with their chosen practice. Our empirical strategy is to exploit changes in market structure at the local level, specifically within-practice changes in the number of GPs in other local rival practices. While this design controls for fixed unobservables at the GP and local area level, it is possible that GPs sort into areas in which there are easier to treat patients or respond to increased competition by selecting easier-to-treat patients for whom it is easier to achieve quality indicators. Moreover, areas where population density increases are likely to experience an increase in the number of GPs. Practices in such areas will find it easier to produce higher quality if the increase in density is driven by the entry of more mobile populations who tend to

[3] All our data are for UK financial years which run from 1 April to 31 March.

be healthier (Hayes et al., 2017). Such practice level patient changes will lead to overestimates of the effect of competition. To avoid this, we control for a large set of time-varying measures of the health and socio-economic status (SES) of the population of the local area from which the practice may draw its population and for population density. This design allows us to address the potential endogeneity which would arise if areas with better amenities attract more doctors or healthier patients for whom it is easier to achieve higher clinical quality. In robustness tests we consider alternative measures of competition facing general practices, allow for changes in the composition of GPs in the practice and its rivals to isolate the effect of increased effort from changes in GP composition, and also exploit a policy change that increased supply of GPs in some areas but not in others.

Our results show that an increase in the number of GPs in rival practices is associated with increases in both clinical quality and, especially, patient satisfaction. None of our results suggest that greater competition reduces quality. However, in common with results from studies of pay for performance and other policies aimed at improving the quality of care provided by family doctors (Scott et al., 2011), the magnitude of the effect of a change in competition is not large.

Our findings contribute to the literature on quality competition in physician markets and to the debate about whether policies to strengthen competition in these markets should be pursued. In the European setting where there is no price competition amongst providers (providing the ideal setting for examining pure quality competition), there are few studies of the physician market and quality. In the main this literature lacks the exogenous variation needed for causal inference, uses a limited number of outcomes measures, some of which have an ambiguous relation to quality, or analyses small area, rather than firm (physician practice) variation. Schaumans (2015) and Pike (2010) exploit only cross–sectional variation. The former examines the effect of competition in the Belgian family doctor market on pharmaceutical prescriptions. Prescriptions have no direct effect on practice revenue or cost but may make the patient feel that the doctor is taking their health concerns seriously. The unit of analysis in Schaumans (2015) is the small area and she finds little effect. Pike (2010) undertakes analysis at the physician practice level and, as in our study, uses a distance based measure of competition and examines a subset of the quality measures we examine here. He finds that practices with more nearby practices have higher quality. However, as the data is cross-sectional in both these studies, the associations may reflect factors other than spatial competition between doctors.

Brekke et al. (2017) have rich data at the individual physician level and exploit the fact that Norwegian doctors practice in two different settings: their own offices where they see their own patients, and local emergency clinics where they see their own and other GPs' patients. They argue that this means that GPs face greater competitive pressure when they practice in their own offices and thus will be more responsive in this setting. They examine one outcome: the dispensation of 'sick notes' (documents which allow individuals to take time off work with no financial penalty). The setting provides a robust design which allows controls for physician effects, patient effects and physician-patient pair effects. But the outcome variable is not a measure of clinical quality but of responsiveness to patients and may have ambiguous welfare implications if physicians over-prescribe notes to attract patients. More problematic is that the definition of competition: what they examine is not spatial competition but physician behaviour under different contracting arrangements.

The closest research to our paper is Dietrichson et al. (2016). This exploits a reform in Swedish primary care which led to greater entry of providers in municipalities where there was lower availability of providers pre-reform. The authors study both clinical and patient satisfaction measures of quality at the municipality level. They find small improvements in subjective overall quality measures, but no change in avoidable hospitalisations or patient satisfaction with access to primary care. However, although their policy experiment provides a nice context, their unit of analysis is not the firm (the practice) but the municipality. This means that they cannot rule out the possibility that average municipal quality was affected by other municipality level factors, such as an overall increase in the physician-patient ratio, rather than increases in competition facing individual providers.

Research on market structure in physician markets where price and quality are set simultaneously is mainly from the USA and is also limited compared to studies of hospital markets. The research primarily focuses on the impact on prices rather than quality (Baker et al., 2014; Sun and Baker, 2015). It also has to address the fact that prices are increasingly set by complex bargaining between insurers and hospital (see, for example, Clemens and Gottlieb, 2017). The European setting, in which prices are set nationally and patients are generally fully insured, provides a cleaner setting for an examination of the relationship between quality and market concentration in small localised physician markets. It is also particularly relevant to discussions about increasing the role for regulated prices as a way of promoting quality competition in the US healthcare market (Glied and Altman, 2017).

The next section provides a brief account of the institutional framework for English general practices and of policies potentially affecting the amount of effective competition that practices face. Section 3 sets out the estimation methods and strategies for identifying the effect of competition. Section 4 describes the data. Results are in Section 5. Section 6 concludes.

2 Institutional background

The English NHS provides health care which is tax-financed and free at point of use.[4] NHS primary care is provided by family doctors (GPs) organised into small groups, known as general practices. All individuals resident in England are entitled to register with a general practice, and have incentives to do so as practices both provide primary care and act as the gatekeeper for elective (non-emergency) hospital care.

In our study period (2005 to 2012) there are over 8000 general practices in England with an average of just over 4 (4.2) GPs and 6,600 patients (HSCIC, 2015).[5] Most are located at a single site though around 15% have more than one. Almost all are owned by partnerships of their GPs. Larger groups and chains have been absent until recently and are still rare. The NHS contracts with the practice rather than the individual GPs. Practices are paid by a mix of lump-sum payments, capitation, quality incentive payments, and items of service payments. Around 75% of practice revenue varies with the number of patients registered with the practice.[6] Practices are reimbursed for the costs of their premises and information technology but fund

[4] A small charge is made for dispensed medicines, but because of exemptions on grounds of age or low income, this is only applied to around 10% of prescriptions.
[5] Under 10% of GPs are single-handed (i.e. practices with only one GP). GPs do not work across practices.
[6] Over 50% is from capitation payments determined by a national formula which takes account of the demographic mix of practice patients and local morbidity measures. Quality incentives from the national Quality and Outcomes Framework (QOF) (Roland, 2004) generate a further 15% of practice revenue and for a given quality level QOF revenue increases with the number of patients. Practice payments for providing specific services including vaccinating and screening target proportions of the relevant practice population also increase with the total number of patients registered with the practice.

all other expenses, such as hiring nurses and clerical staff, from their revenue. A very rough estimate, under the assumption that average revenue and cost per patient are constant, is that an additional patient registered with the practice produces revenue of £135, expenses of £80, and net income of £55 per practice partner.[7] Thus practices have an incentive to attract patients.

The operation of practices is overseen by area-based NHS administrative bodies known, during the period of our study, as Primary Care Trusts (PCTs). PCTs contained on average 350,000 patients and 55 practices. Practices are required to accept all patients who live within their agreed catchment area set by agreement with their PCT unless they notify the PCT that they are full and temporarily not accepting patients for between 3 and 12 months. Around 2% of practices have such closed lists at any one time.[8,9] However, while some practices may be temporarily closed, this does not mean there is no choice for patients. On average patients in small homogenous geographical areas that contain on average 1500 people are registered with 13 different practices.[10] This means practices potentially face a high degree of competition for patients. On average practices have 25 rival GPs located in practices within 2km (more details in Section 4 below).

Government policy over a relatively long period has been to increase competition between practices. The national body which regulated the location of general practices was abolished in 2002 and replaced by a tendering process, run by the local administrative bodies responsible for over-seeing health care delivery, and intended to make it easier for new practices to be established. Restrictions on the type of organisation which could provide general practice services were also eased in 2004, so that general practices can be run by other NHS institutions

---

[7] In 2009/10 there were 26,420 GP contractors (i.e. joint owners rather than salaried employees) in England with average gross income £287,100l, expenses of £168,700 and net income of £109,400. There were 2066 registered patients per GP contractor. See: GP Earnings and Expenses 2009/10, http://www.hscic.gov.uk/pubs/gpearnex0910 (last accessed 10 March 2015); General and Personal Medical Services, England 2001-2011, http://www.hscic.gov.uk/catalogue/PUB05214 (last accessed 10 March 2015).

[8] House of Commons, Hansard Written Answers for 28 Apr 2008.

[9] Practices with closed lists are not eligible for certain types of payments for providing additional services. Consequently some practices designate themselves as 'open but full'. Estimates suggest that in 2007 up to 10% of practices were 'open but full' at any time (National Audit Office, 2008) but, since the designation is unofficial and has no legal force, its extent and effect on patients signing up to the practice are unclear. GPs can deregister patients if there is a fundamental breakdown in the doctor-patient relationship. It has been estimated that each year 0.1% of patients are deregistered (Munro et al, 2002). If a patient cannot find a practice prepared to accept them, they can ask their PCT to find them a practice, and PCTs can assign patients to practices. Around 0.5% of patients are assigned to practices (Audit Commission, 2004).

[10] The area is the Lower Super Output Area (LSOA), discussed in more detail in Section 4 below.

such as hospitals, and by private companies, as well as traditional partnerships of GPs. Practices cannot advertise for patients but, in a drive to increase choice by patients in all areas of English healthcare, the national government established the NHS Choices website in 2007. The website contains information on the characteristics of general practices, including the specialist clinics they offer and results from patient satisfaction surveys. These data are published with the express aim of increasing choice and, through this, improving quality.[11]

During our sample period there was a major national policy initiative to increase the supply of family doctor care. Known as the Equitable Access to Primary Medical Care (EAPMC) policy, the aim was to increase supply in the 38 PCTs (out of a total of 151 PCTs) in which there was evidence of a shortage of GPs relative to patient need (Asaria et al, 2015; Department of Health, 2007). The policy, funded with £250 million from central government, operated from financial year 2008 to 2011 and increased the supply of GPs in the 38 EAPMC PCTs relative to other PCTs (Asaria et al., 2015). We make use of the policy in one of our battery of robustness tests.

3 Empirical strategy

Our empirical approach is to examine the quality change in a practice following a change in competition from rival GP practices, exploiting the fact that we observe the universe of GP practices over an eight year period. Our basic model is

$$y_{jt} = \beta_t + \delta m_{jt} + \mathbf{x}'_{jt}\boldsymbol{\beta}_x + \alpha_j + \varepsilon_{jt} \qquad (1)$$

where y_{jt} is the quality of practice j in year t, β_t is a year effect common to all practices, m_{jt} is the measure of competition facing practice j in year t, $\mathbf{x}_{jt}$ is a vector of case-mix controls measured either for the practice list population or for the local population, and α_j is a time invariant practice fixed effect. The data period is eight financial years 2005-2012. We estimate this model for all practices in England and also for practices located in homogeneous areas. The coefficient of interest is δ. Details of how we measure quality, competition, the set of rival practices and the covariates are presented in section 4.

[11] The NHS Choices website states: "The idea is to provide you with greater choice and to improve the quality of GP services over time, as GPs providing a good service are naturally more popular."AboutNHSservices/doctors/Pages/patient-choice-GP-practices.aspx http://www.nhs.uk/ NHSEngland. http://www.nhs.uk/choiceintheNHS/Yourchoices/GPchoice/Pages/ChoosingaGP.aspx. Detailed information on performance of practices in an area under the national pay for performance scheme is also available via http://www.qof.ic.nhs.uk/search/ and information from surveys of patient satisfaction is available at http://www.gp-patient.co.uk/info/.

In estimating this model we need to deal with a number of issues that threaten identification of the competition effect. First, common to estimation of the impact of market structure on quality in all health care markets, including primary care, is that any measure of outcome needs to be adjusted for patient case-mix. Second, practice location is not exogenous to the patient or the GP. If easier-to-treat patients sort to practices that are of higher quality, the effect of competition will be over-estimated. Alternatively, if an increase in quality attracts the harder-to-treat patients, the effort effect of competition will be underestimated. Relatedly, where to locate is also chosen by GPs and practices. As practices are not allowed to refuse patients from within their agreed catchment areas and practices are rewarded on the basis of performance as well as number of patients, it is possible that practices choose to locate in areas in which patients are easier to treat (typically those areas in which patients are healthier and more affluent). If so this will upwardly bias estimates of the impact of competition. Alternatively, if practices are less likely to enter near a practice which provides high quality, this will downwardly bias the estimated effect of competition on quality.[12]

The third issue is the choice of the measure of competition. We have to define the market in which practices operate and what is a measure of a change of competition. We define a market as a fixed radius around a practice and a change in competition as a change in the number of rival GPs in this market. (We discuss the rationale for these two choices in section 4 below and subject both to a number of robustness checks.) Given this choice, an increase in our competition measure may be due to an increase in population density if this leads to the entry of more practices or to existing practices taking on more GPs. If this is the case, an increasing number of rival physicians may not imply greater competition for patients since the number of patients in the area will also have increased. Moreover, an increase in population density may also lead to a local population which is healthier if there is a healthy migrant effect. It is also possible that an increase in population in an area leads existing practices to take on additional GPs who are more motivated than the existing stock and so produce higher quality. In this case, the increase in quality would be wrongly attributed to effort rather than a change in the composition of the GPs in the practice.

[12] This is similar to the problems encountered in estimating the effects of hospital competition (see, for example, Kessler and McLellan (2000) for the USA and Gaynor et al. (2016) for the UK).

We address these concerns in the following way. Our fixed effects specification controls for unobserved time invariant patient characteristics and time invariant characteristics of GPs in the practice and its rivals and the area the practice is located in. We have a rich set of time time-varying casemix controls that we can also include in our models. At the practice level we have a large number of measures of the health of the practice population. At area level we have controls for population density, demography, morbidity, SES, and the attractiveness of the area to GPs.

We begin by comparing models with and without casemix and other controls. If the results are robust to exclusion of these measures, it suggests that selection on observables is not a problem and hence possibly there may be little bias from selection on unobservables. Second, we replace the case-mix controls based on the characteristics of the actual practice patients with measures of the same characteristics for the local population from which the practice could potentially draw its patients. This allows us to address confounding associated with changes in the practice population in response to quality change. Third, we undertake an analysis using only those practices located in areas with homogeneous socio-economic characteristics. We argue that practice location and patient selection of practices in these homogenous areas is exogenous to amenities and unobserved population type, because amenities and population type do not vary within these areas. Hence in such areas we can identify the effect of market structure by its within area variation (as in Gravelle et al, 2016). We therefore carry out a sub-set of analyses only for practices in small geographical areas characterised by low variance in their population type as measured by small area social and economic deprivation of the population (more details are provided in Section 4).

Fourth, we undertake robustness checks of the definition of the market. Fifth, to address concerns that increases in demand lead to changes in the composition of the GPs in the local market, we estimate models controlling for the composition of GPs in the practice and that of their rivals. Finally, to address potential endogeneity of change in the number of GPs as a function of quality (practices may not choose to expand when located near a high quality practice) we exploit the EAPMC policy. This policy exogenously increased the number of GPs in EAPMC PCTs relative to non-EAPMC PCTs (Asaria et al., 2015). While the details of this policy are not well articulated in policy documents – for example, the exact algorithm for choice of treated PCTs is not made public and when exactly post-2009 PCTs spent more on GPs is not clear – it did increase our measure of competition. Post-policy, practices located in

EAPMC PCTs faced a larger increase in the number of GPs in nearby rival practices than practices located outside EAPMC PCTs.[13] We therefore use this policy to test for the effect of an increase in the number of rivals which is not confounded by practice choice of location. To overcome the problem of specifying the exact date at which the policy was implemented in each treated PCT, we estimate long difference models in which we compare the changes in quality in practices before and after the introduction of the EAPMC in the 38 EAPMC PCTs with the changes in quality in practices in 113 non-EAPMC PCTs. To allow for the fact that treated PCTs are not random (by definition they are those where there was considered to be a shortage of family doctor care relative to need), we also estimate the same model using only those practices located within 2km of the border of an EAPMC PCT.

In a selection-on-observables design, it is not possible to control for all potential confounders. For example, there may be remaining changes in practice populations that we do not observe that may bias our estimated effect of competition on quality. However, as discussed above, it is not clear *a priori* which way these unobservables would affect the estimated effect. We consider that the large set of observable controls that we use in our design (discussed in Section 4), and the different estimation strategies we adopt (outlined here), should mitigate concerns that the effects we find are driven by unobserved changes in patient type or area changes that might be linked to the production of quality and to our spatial measures of competition.

4 Data

4.1 Quality

To capture the multi-dimensional nature of health care quality we use three measures of clinical quality and three of patient reported experience.

Clinical quality. We measure the clinical quality of care in the practice with data from the national Quality and Outcomes Framework (QOF). Almost all practices take part in the QOF, which rewards practices for achievement on a large number of quality indicators. Some indicators are linked to record keeping – for example, the percentage of patients with

[13] Post-policy, practices in EAPMC PCTs had an average increase of one more rival GP (within 2km) than practices located outside EAPMC (Appendix Table A5. The within practice variance in the number of rivals within 2km for the whole sample is 6.8, so an increase of one rival GP is a relatively large within-practice change.

hypertension whose notes have a record of blood pressure in the previous 9 months. Some are for treatment − for example, the percentage of patients with coronary heart disease currently treated with a beta blocker. And some are for intermediate health outcomes − for example, the percentage of patients with diabetes whose last HbA1C reading is 7.4 or less. Better achievement increases the number of QOF points (up to a maximum of 1000) and practices are paid an average of £125 per point. We use the percentage of total available points which the practice achieved as a measure of quality (*QOF points*). It has the merit of being simple and readily observable by patients and physicians.

Total QOF points has some drawbacks as a measure of clinical quality. First, only around two thirds of the points are for indicators of clinical quality for specific conditions. The others are related to more general aspects of practice management, for example record keeping or providing information to patients. Second, for most condition specific clinical indicators, increased achievement on the indicator does not affect the number of points awarded if the percentage of relevant patients for whom the indicator is achieved is less than a lower threshold (usually 40%) or above an upper threshold (which ranged from 60% to 90%).[14] Third, the number of points earned on these indicators is based on reported achievement measured as $100*N/(P–E)$, where N is the number of patients for whom the indicator is achieved, and P is number of patients with the relevant condition. E is the number of patients with the condition who are exception reported for the indicator by the practice, for example because the patient refused to attend or there were contra-indications for treatment.

To deal with potential gaming of exception reporting patients as ineligible for an indicator (Gravelle et al., 2010), we measure performance on a given indicator as population achievement $100*N/P$. This is the percentage of patients with the relevant condition for whom the indicator has been achieved and is not affected by exception reporting (Doran et al., 2006).[15]

---

[14] Very few practices fail to achieve the lower threshold. Many practices exceed the upper threshold for an indicator and so would earn no additional financial reward by achieving the indicator for more patients. This may occur because (a) some indicators apply to small numbers of patients: a practice with 5 patients with the relevant condition for an indicator with an upper threshold of 65% would have to achieve the indicator for at least 4 (a population achievement rate of 80%) to earn the maximum points; (b) practices may be risk averse and over achieve to guard against treated patients leaving the practice before the financial year end when achievement is calculated; (c) GPs have intrinsic motivation and care directly about patient outcomes.

[15] We also estimated models for reported achievement and the results were very similar to those for population achievement, suggesting that any reporting of patients as ineligible does not affect our results. The correlation of reported and population achievement was 0.83 in our data.

As our second measure of clinical quality we use *PA clinical*: the weighted average of the percentage of patients with the relevant condition for whom the indicator is achieved, taken over the 42 clinical indicators which were consistently defined between 2005 and 2012. The weights are the maximum points available for the indicators.

As a third measure of clinical care quality we use the number of emergency hospital admissions of practice patients for Ambulatory Care Sensitive Conditions (ACSCs). These are conditions for which emergency admissions could be reduced by good quality primary care. We use the definition provided by Harrison et al. (2014) to count the number of emergency admissions for ACSCs per 1000 patients (*ACSC rate*) for each practice in each year from 2005 to 2012.[16]

Patient reported quality. We construct patient reported measures of quality using responses to three questions in the national General Practice Patient Survey (GPPS) administered to a random 5% sample of patients in each practice in each year from 2006 onwards. *Open hrs sat* is the percentage of respondents satisfied with their GP surgery opening hours (available for 2006-2012); *Care sat* is the proportion of patients satisfied with overall care in their practice (available for 2008-2012); *Recommend* is the proportion of patients who would or might recommend their practice (available for 2009-2012).[17]

The within-practice (demeaned) correlation coefficients of these measures are reported in Appendix Table A2 for the years 2009-12 (the period for which all variables are available). The correlation between the clinical quality and the satisfaction measures is low, indicating that they measure different aspects of quality. The correlations within the clinical and satisfaction measures are higher, but not so high that the measures of quality are simply duplicates of each other.

[16] Some ACSCs are incentivised by the QOF (e.g. diabetes, asthma) whereas others are not (e.g. anaemia, cellulitis and perforated ulcer). We count both incentivised and non-incentivised ASCS emergency admissions using the admission method and diagnostic fields in the Hospital Episode Statistics (HES) dataset.

[17] The wording of the questions changed somewhat over the sample period but we assume that including year dummies in the regression models will allow for this. In other work on the determinants of ACSC admission rates using these variables, we also interacted them with year dummies and found that the interactions were small and rarely significant (available from the authors on request).

4.2 Competition

Competition in general practice care takes place in a local market since patients seek care by going to their practice in person (or, more rarely, a practice GP coming to their home). As a result, the probability that a patient is registered with a practice declines rapidly with the distance of the practice from their home. Around 40% of patients register with the nearest practice. A study of a large English region found that the median distance to the nearest practice was 0.84km (mean = 1.2km) and the median distance to the chosen practice was 1.48km (mean =1.88km). The same study also found that the cross-practice elasticity of demand with respect to quality declined rapidly with distance (Santos et al, 2017).

The smaller the radius used to define the market area for a practice, the greater the proportion of practices with no measured competition, and the smaller the proportion of patients who choose a practice within this distance. Appendix Table A3 shows these statistics for radii ranging from 0.5 to 5km. On the basis of these distributions, we use a 2km radius to measure the market area for a practice. Only one tenth of practices have no rivals within 2km and over two thirds of patients choose a practice within this distance.

In defining the number of rivals within this market, we had two choices. The first was the number of rival practices with a branch surgery within a defined radius of any branch of the target practice. The second choice was the number of full time equivalent (FTE) GPs in rival practices within this radius.

Over the period we study the number of practices fell from 8451 in 2005 to 8088 in 2012 as small practices have closed. But the total number of GPs increased from 32,738 to 35,415, resulting in an increase in the number of GPs in each practice and a fall in the ratio of patients to GPs (from 1613 to 1574). Thus the change in the number of practices within a given distance from a practice is a poor measure of the change in the capacity of rival practices to enrol its patients. Therefore we use the number of full time equivalent (FTE) GPs in other practices within 2km as the measure of competition. Just over 10% of practices have no rivals within 2km (Appendix Table A3). They are predominantly in rural areas. Many practices face a large number of rival GPs within this distance. About 20% have between 1 and 10, and 70% have more than 10. Figure A1 shows the spatial distribution of the GP practice surgeries across England in 2010. In robustness checks we examine different definitions of the market.[18]

4.3 Covariates

To control for potential selection of practices by patients, patients by GPs, and of location by practices and patients, we utilise a large set of time varying covariates measuring demography, morbidity and SES. We estimate models with practice level measure of the covariates and also, to further guard against selection into the practice list, we estimate models with the covariates measured at the level of the local area from which patients could potentially travel to the practice.

We allow for demography by using 10 age-gender bands and population density. We use three types of morbidity measure. The first is based on the practice prevalences of ten conditions (CHD, stroke, hypertension, diabetes, epilepsy, chronic obstructive pulmonary disease (COPD), hypothyroidism, cancer, serious mental illness, asthma) recorded as part of the QOF. The second is the proportion of patients in a practice who are resident in nursing homes. The third is the proportion of the population in small areas who are receiving incapacity benefit or disability allowance (IBSD). We use small area data from domains of the Index of Multiple Deprivation (IMD) on income, education, crime, and the living environment as measures of SES and the attractiveness of an area. Areas with higher IMD rankings are *less* deprived.

Population density is available for Middle Layer Super Output Area (MSOA) census areas which have mean populations of 7,200. We use the mean density over all MSOAs in which the practice has a branch. Age-gender band demographic data is available both for practices and for small areas. To construct the local area demographic variables we take population weighted averages of the data in each MSOA census areas in which the practice has a branch.

[18] These include models with the number of rival practices, the characteristics of GPs in rival practices, and allowing for non-linear effects. We do not use competition measures, such as the Herfindahl-Hirschman Index, which are based on market shares because these are endogenous. Using predicted market shares based on choice models which exclude quality, as in the literature on hospital competition (Kessler and McClellan, 2000) is complex to construct given that the number of practices is orders of magnitude greater than the number of hospitals. Since the main non-quality factor affecting demand is patient-to-practice distance (Santos et al, 2016), it would likely produce competition measures highly correlated with our measures.

The other variables are available only for practice populations or only for small areas. We attribute them as necessary to construct measures both practice populations and the populations of the local area in which the practice is located. For the disease prevalences of the local area in which the practice is located and the proportion of the population in nursing homes we use the means of these variables for the practice and the nearest five other practices. IBSD and the SES measures are attributed to practices as the means of the Lower Layer Super Output Area (LSOA) level values weighted by the proportion of the practice list resident in each LSOA.[19]

Summary statistics for the covariates are in Table A1.

4.4 Sample selection

Our main estimates use an unbalanced panel of all practices in England after dropping practice-year observations in which the list size was under 1000 or there was missing data on covariates.[20] In a test of potential endogenous selection of location by practices we re-estimate our baseline model (Eq. 1) on a sub-sample of practices in areas which are homogeneous in terms of SES. Our assumption is that within these areas the small variation in SES of the population will mean that practices have less incentive to locate at one address versus another. This should serve to reduce concerns that our estimates are biased by unobserved population sorting across practices, driven either by patient selection of practice or practice selection of location.

In choosing homogenous areas we face a trade-off. Using a larger geographical unit will provide more within-area variation in practice competition and hence increase precision in estimating the effect of competition. But it will make it less plausible that there is little within-area variation in unobserved factors that might affect practice location. PCTs contain around 50 practices and have populations of over 300,000 on average, so are too large. Instead we use the smaller areas defined by Parliamentary Constituencies, which contain on average 15 GP practices and a population of just under 100,000. We select a subset of Parliamentary Constituencies which are homogeneous in terms of the SES of the small areas (LSOAs) within

[19] There were 6781 MSOAs and 32,482 LSOAs in England defined by the 2001 census. (Our data at these levels data is time varying.)

[20] We also drop practices in the Isles of Scilly.

them. To do this, we compute the coefficient of variation in SES (as measured by the overall IMD score) across the LSOAs contained within each Parliamentary Constituency.[21] We then select all practices in Parliamentary Constituencies in the bottom quintile of the distribution of the coefficient of variation of the IMD. Thus each practice in the sample is in an area (Parliamentary Constituency) within which there is relatively little variation in the SES and so less likelihood of variation in unobserved SES factors which influence practice location and quality.

Some of the Parliamentary Constituencies we select will have little variation around a lower deprivation (high IMD) score and others will have little variation around a higher deprivation (low IMD) score. But over all the selected Parlimentary Constituencies, the practices exhibit considerable variation across the full range of IMD scores.

4.5 Summary statistics

Summary statistics for our main competition and quality variables are in Table 1. The first 6 rows present the measures of quality. Higher numbers indicate higher quality, with the exception of the ACSC rate where a higher number is a worse clinical outcome. All measures exhibit considerable variation, and a relatively high proportion of this is within-practice, aiding identification. The last row present our main measure of competition: the numbers of GPs in rival practices within 2 km. There are on average just over 25 within 2km.[22]

Our estimated effect of competition is based on the correlation between changes in the number of rivals and changes in quality. As a preliminary examination of this relationship, Figure 2 presents scatter plots of the six measures of practice demeaned quality against practice demeaned competition. For all measures of quality there is either a positive or a non-negative relationship between (demeaned) quality and (demeaned) competition.[23]

---

[21] On average there are just over 60 LSOAs per Parliamentary Constituency.

[22] Appendix Table A3 has the statistics for other radii.

[23] Figure A2 has scatter bin plots of the same data and shows similar patterns.

5 Results

Table 2 presents the coefficients on competition and measures of goodness of fit from models estimated for the full sample of all practices over the full period for which the data are available. *Panel A* has the pooled OLS results from a bivariate regression of quality on competition with no controls for practice population or morbidity. This shows significant negative relationships between the number of rival GPs faced by a practice and both clinical quality (with the exception of the ACSC measure where the negative coefficient indicates a positive correlation with quality) and patient satisfaction and reflects the lower quality achieved by practices in urban areas. *Panel B* adds practice fixed effects and shows that once these are allowed for the association between number of rivals and quality becomes positive for all measures of quality. *Panel C* adds controls for population density, practice list size, and practice patient covariates for demographics, morbidity, and SES. The pattern of competition effects is similar to Panel B though the coefficient estimates are somewhat smaller. *Panel D* addresses the concern that practices may select patients based on their characteristics and that this will bias the estimated competition effect. Instead of covariates measured at practice level we use demographic, morbidity, and SES controls measured at the level of the local area potential patient pool that might use the practice. The model also does not include practice list size to avoid endogeneity bias arising because patient choice of practice is affected by quality. The coefficients on competition are somewhat larger than in Panel C and are statistically significant for five of the six quality measures.[24] The broad similarity of the estimated effects of competition in Panels B, C and D suggest that time varying endogenous selection of by patients and practices is not a serious problem. However, our preferred estimates are those in Panel D as these control for changes in the nature of the population in the local area.

To further test whether the results are driven by (unobserved) differences in patient case-mix, we restrict the sample to practices in areas that are more homogeneous in population characteristics. We re-estimate our preferred model (Table 2, *Panel D*) using only the sample of practices in the most homogenous Parliamentary Constituencies. The results are in Table 3. The coefficient estimates on the number of rival GPs for the clinical quality measures are similar to those for the full sample. The coefficient estimates for the patient ratings are similar

---

[24] The full set of estimates for this model are presented in Table A4.

or slightly larger than those for the full sample. This similarity across samples again suggests that selection of patients may not be an issue in our context.

5.1 Robustness tests

We now subject our estimates to a series of tests with respect to the definition of the local market, the measure of competition and measurement error, designed to address the concerns over identification discussed above.

Local market

Our design entails choice of a fixed radius for the size of the market. While the choice of 2km is motivated by the data on travel patterns and GP location (Appendix Table A3), this is just one potential definition. In Table 4 we explore robustness to variation in this spatial definition. We re-estimate our preferred model (Table 2, Panel D) for 5 radii ranging from 0.5km to 5km. At the smallest radius of 0.5km, there is no association between clinical quality and competition, but that between satisfaction and competition remains, albeit less precisely estimated. Results at 1km, 3km and 5km are similar to those at our preferred 2km radius. The magnitude of the coefficients on competition generally fall as the radius increases, at least partly because the scale of the competition measure (the number of rival GPs) increases and that of the quality measures do not. We conclude that, with the exception of the smallest radius, the results are robust to the particular small radius chosen.[25]

A related potential threat to our identification strategy is that we are picking up changes at the PCT level that lead to increases in both numbers of GPs in the local area, and so the number of rivals, and in own practice quality. To examine this, we first cluster the standard errors at the PCT level. This makes almost no difference to standard errors (Table 5, *Panel A*).[26] Next, we add controls for PCT-year effects. This will control for local policies which may have increased quality and number of GPs in all practices, which we could incorrectly attribute to an increase in rival GPs. This is a tough test, as it means all identification comes from practice within-year-

[25] The smallest radius of 0.5km assumes a very small market relative to the average distance between patients and practices (1.2km) and 40% of practices have no rival GPs within this distance and it is thus probably too small to be a useful definition.

[26] The (very small) change in the coefficients compared with Table 2, Panel D is because we had to drop a few practices which could not be assigned to the same PCT in all years.

PCT variation in number of rivals, which is smaller than the practice within-year variation. The results are *Panel B* of Table 5. The association with clinical measures becomes small and statistically insignificant, but the association with two of the patient satisfaction remains positive and well defined, albeit smaller than in our preferred model. As an increase in the number of rivals maybe driven by PCT-level policies, controlling for year*PCT effects maybe over-controlling. If, for example, the within-year PCT increase in number of rivals is what practices respond to, then by adding year-PCT effects we wipe out this legitimate variation.

One way to address concerns over potential endogeneity of entry and exit of patients – and thus changes in patient type - in response to competition is to undertake the analysis at a larger spatial level than the level at which patient flows arise. We know that most patients choose practices close to their homes. In addition, most patients select practices within their local PCT. PCTs are also large and contain around 50 practices. Therefore an analysis at PCT level should mitigate any effect of patient movement between local practices as a result of quality changes. We therefore aggregated the data to PCT level, using practice list size weighted means of all the variables, and re-estimated our preferred specification (Table 2, Panel D). We find (*Panel C* of Table 5) that increases in competition are positively associated with increases in quality for five of the six measures. The associations are somewhat smaller in magnitude and not statistically significant, possibly because of the very large reduction in the number of observations and the reduction in the variability of competition and quality measured as PCT level means.

It is possible that quality measures do not adjust immediately to GP efforts. For example, QOF indicators based on intermediate health outcomes, such as the percentage of diabetic patients with controlled blood sugar, are likely to take longer to adjust than those based on recording patient symptoms such as blood pressure. It may also take some time to change patient satisfaction. We therefore estimated models using a one year lag of competition. As this shortens our estimation period, we also re-estimated our baseline model using the current number of GPs for the same shorter period. Results for the lagged competition model in *Panel D* of Table 5 are very similar to our baseline estimates from the model using all years of data and to the model using current competition with the reduced sample.[27]

---

[27] Available from the authors.

We have argued that the number of GPs in rival practices is a better measure of competition than a count of the number of practices because the latter takes no account of rival practices' capacity to take on extra patients. But a counter argument is that a single rival practice with *n* GPs poses less of a competitive threat than two rival practices with *n/2* GPs since practices may be horizontally differentiated by location or other practice characteristics. To test this we add the number of rival practices to our baseline model. The estimated effects of our preferred measure (the number of GPs in rival practices) are unchanged (Table 5, *Panel E*).

We are interpreting our results as effort on the part of GPs. But it may be the case that what we are picking up is changes in the local labour markets for GPs, which drives changes in the number of GPs in own and rival practices and may also change the composition of GPs. For example, in a market where the demand for health care increases, it is possible that the new physicians who enter the market (and lead to an increase in the number of rivals) have higher quality or more motivation than the existing stock of GPs. This would increase quality, but is not a competition effect. [28]

We undertake a number of tests for this, which are reported in Table 6. First, in *Panel A*, we add the number of GPs in the practice as an additional covariate. This allows us to test whether the association of the number of GPs in nearby practice with practice quality could simply be picking up increases in the number of GPs across all practices at the local level. We find that adding the number of own GPs to the model leads to only very small reductions in the estimated effects of our competition measure (the number of GPs in rival practices). Second, to explore the idea that an increase in GPs in a practice may be accompanied by a change in their characteristics, and it is this compositional change that is driving the results, we add characteristics of own GPs (% female, % salaried, % qualified outside Europe, % aged under 40, % aged 40-60) to the model. The coefficients on the competition measure (*Panel B*) again change little. Third, we control for the same characteristics of GPs in rival practices without, and also with, the characteristics of GP in own practice, again to test that the results are not driven by a change in composition of GPs in the local labour market. The results, reported in

[28] We thank an anonymous referee for making this point.

Panel *C* and *D* show that our estimates remain basically unchanged. Thus we conclude that changes in the composition of GPs in the local market are not driving our results.

Measurement error

Fixed effects estimates in short panels may be downwardly attenuated due to measurement error. To address this, we collapse our data to two data points per practice – the average for the period 2009-12 and the average for the period 2005-8 – and examine the change in outcomes as a function of the change in number of rivals (with controls for all covariates). We cannot do this for two of the satisfaction measures as the series do not exist before 2009. The long difference estimates in Table 7 show positive effects of the number of rivals on both clinical quality and patient satisfaction. The estimates are a little larger, and better defined, than our baseline specification.

We conclude from this battery of tests that practices which face more potential competition have higher clinical and/or patient-rated quality, that our results are robust to definitions of the market, changes in the number and composition of local GPs and to measurement error.

Exploiting the EAPMC policy

The EAPMC policy was intended to increase the number of GPs in those PCTs that received funding and those PCTs which received EAPMC funding had a larger than average increase in the number of GPs in rival practices (Appendix Table A5). One design exploiting this increase would be to undertake a difference-in-difference analysis of practices in treated PCTs versus other control practices. Such a design requires an assumption of common trends before the policy date. In addition, the timing of the policy change needs to be known. In our case, these requirements are not clearly met, as the pre-policy period announcement period is only 3 years and so it is difficult to establish whether common trends exist or not and it is not well documented when different PCTs were able to start to spend their funds after the commencement of the policy in 2009. To overcome this in order to exploit this policy change, we simply undertake a long difference analysis in which we collapse the data to one observation per practice - the average for the period 2009-12 and minus the average for the period 2005-7. We then compare the change in outcomes for practices in treated PCTs with those in two sets of non-treated (control) practices.

The first set of control practices are all practices which are not located in a EAPMC PCT. The set of outcome variables is smaller than for the baseline analysis as two of the patient reported outcomes are not available for the full period. The results in Table 8, *Panel A*, show significant association of being in a treated PCT with increases in both clinical quality and patient reported satisfaction. However, as noted above, the PCTs selected to receive extra EAPMC funds were not selected randomly. They differ from other PCTs in terms of competition, clinical performance, patient satisfaction and demographics, deprivation and have higher levels of morbidity (Appendix Table A6). This is as expected, since the scheme was specifically targeted to those PCTs in which access to GP services was perceived to be poorer. To deal with this we exploit the fact that the treated PCTs are scattered across England (see Appendix Figure A1) and share geographical boundaries with non-treated PCTs. The populations along these boundaries are likely to be similar in their socio-economic status and their healthcare need. The secondary care (hospital) facilities available to both practices and patients are also likely to be similar as patients cross PCT boundaries to access hospital care. In *Panel B* we therefore restrict the sample to treated and non-treated practices located within 2km of the shared boundaries.[29] The results in *Panel B* and are very similar to those in *Panel A* though somewhat less precisely estimated, reflecting the smaller sample size.[30]

5.2 Heterogeneity

Our large sample allows us to examine whether there are non-linearities in the effect of increases in rivals for practices facing different initial numbers of rivals. We implement this in two ways, defining a dummy variable with value of one if the practice is in the lowest (highest) quartile of initial competition (defined as the average of financial year 2005 and 2006 value of competition) and interacting the dummy with the linear competition term. Table 9 shows that the effect is either linear (using the lowest quartile as the interaction term) or, for the patient satisfaction measures, concentrated amongst the practices facing the highest competition. We therefore conclude that the association of a change in the number of rival GPs is similar for clinical quality measures across the large range of spatial competition we observe in our data while for patient satisfaction this is concentrated where initial levels of competition are more intense.

[29] See Gibbon and Machin (2003) for this approach in the context of school quality.

[30] The estimate for opening hours changes sign but is not significant in either panel of Table 8.

5.3 Magnitude of the effects

The results broadly support the view that increased competition between GPs in geographical space increases clinical quality or patient reported quality or both. However, the magnitude of the effect is small. For example, the competition coefficient of 0.035 in the baseline model (Table 2, Panel D) indicates that one extra GP in a rival practice increases clinical performance, as measured by population achievement (the percentage of the practice population for whom the QOF clinical indicators have been achieved), by 0.035%. This is less than 0.01 of the standard deviation of the clinical quality measure and even a one standard deviation increase in competition would have resulted in an increase in population achievement of less than one fifth (0.17) of its standard deviation. A one standard deviation increase in competition would increase the percentage satisfied with care by 1.3% or 0.20 of its standard deviation. The long difference estimates of the effect of EAPMC are also modest: population achievement increased by 0.58% (under 1% of the standard deviation) in EAPMC practices relative to practices in non-EAPMC PCTs.

While these are small effects, they need to be set in the context of production of clinical quality in general practices. In this setting, individual policy interventions do not have dramatic effects. For example, the UK QOF was the world's largest pay for clinical performance scheme, at a cost of around £1 billion per year. It had no detectable effect on overall population mortality, nor on mortality from ischaemic heart disease (one of the most strongly incentivised parts of the QOF, Ryan et al., 2016), nor on premature mortality (Kontopanatelis et al., 2015). It also had, at best, small effects in improving quality of care for chronic diseases which was its main rationale (Gillam et al, 2012; Guthrie, 2016). Other incentive schemes policies for family physicians have had similarly modest effects (Scott et al., 2011). And in similar institutional settings to the UK NHS, both Brekke et al. (2017) and Dietrichson et al. (2016) also find modest effects of competition on GP quality.

6 Conclusions

In this paper we examine the relationship between market structure and quality in healthcare. We exploit the universe of all family physician practices in England to examine whether increased potential competition from rivals increases quality. There is no price competition as patients are fully insured, so this is an ideal setting in which to examine the relationship between market structure and quality.

In common with the literature on hospital and physician markets, we define potential competition spatially, basing the distance defining the local markets faced by providers on studies of patient choice in the English market. To derive plausibly causal estimates we use within-practice estimators with a large number of controls that allow us to deal with patient and practice selection of location. In contrast to most other studies of healthcare markets, we examine the effect on both clinical and patient-assessed measures of quality. Thanks to the fact we have data on the universe of all practices (firms) in the market, we subject our estimates to a number of robustness tests to deal with potential threats to identification and examine heterogeneity in the effect of rivals. We also able exploit a policy shock which was intended to increase the availability of family physician care in selected areas.

We find that increases in the number of rival practitioners and quality are positively associated. The association is more consistent and stronger for our three measures of patient satisfaction. They are weaker for two of our three measures of clinical care: total points achieved in the national quality pay for performance scheme and emergency hospital admissions for conditions which for should be managed in general practice. This may be because only two thirds of total points are earned for quality of care for specific conditions and emergency admissions depend in part on local hospital admission policies.

Our results do not appear to be driven by patient selection of practices or practice selection of patients, endogeneity of GP location or changes in the composition of general practitioners in the local market. However, the effects are small (as have been other estimates of GP responses to competition in similar general practice markets). This may reflect the fact that physicians' efforts to improve quality are driven by considerations that are not purely financial, such as a concern for patient wellbeing and professional norms (McGuire, 2000; Benabou and Tirole, 2006; Rebitzer and Taylor, 2011). But it may also be due to that fact that entry into this market is still relatively heavily regulated, protecting practices from the impact of rivals.[31]

[31] Entry decisions into primary care provision have been heavily influenced by local bodies (Primary Care Trusts and their successors) that are dominated by GPs.

More generally, our results provide some support for policies which seek to increase the demand elasticity facing physicians in local markets. Examples include policies to provide greater information and the loosening of entry restrictions (as in the U.S., The Netherlands, Germany, the U.K., Sweden and Norway). The setting we examine – fully covered patients and physicians reimbursed by centrally determined prices or funding – is common in health-care systems. The financial incentives facing family physicians in many health-care systems are similar to those we examine here: to attract patients to earn revenues subject to convex effort costs. This all suggests that the results we find are likely to be generalisable to contexts outside the U.K. setting, although empirical testing of this is clearly required in any specific institutional context.

Finally, although we have shown evidence of a positive effect of competition on quality of care, this does not answer the normative question of whether welfare is unambiguously increased by greater competition. What our results do suggest is that benefits from competition should enter into any social cost–benefit analysis of policies to increase information and relax constraints on choice of family physician (Mays et al., 2014; Siciliani et al., 2017).

References

Agency for Healthcare Quality and Research. (2007). AHRQ Quality Indicators — guide to prevention quality indicators: hospital admission for ambulatory care sensitive conditions, Rockville, MD: Pub. No. 02-R0203. Available at: http://www.qualityindicators.ahrq.gov/Downloads/Modules/PQI/V31/pqi_guide_v31.pdf (last accessed: 5 March 2015).

Asaria M, Cookson R, Fleetcroft R, Ali, S. 2015. Unequal socioeconomic distribution of the primary care workforce: whole-population small area longitudinal study. *BMJ Open* 2016; 5e0088783. doi:10.1136/bmjopen-2015-008783.

Baker L, Bundorf M, Royalty A, Levin Z. 2014 Physician practice competition and prices paid by private insurers for office visits. *Journal of the American Medical Association* 312(16):1653–62.

Bénabou, R., Tirole, J. 2006. Incentives and prosocial behavior. *American Economic Review*, 96, 5, 1652-1678.

Berry S, Waldfogel J. 2001. Do mergers increase product variety? Evidence from radio broadcasting. *Quarterly Journal of Economics* 116 (3): 1009–25.

Bloom N, Propper C, Seiler S, Van Reenen J. 2015. The impact of competition on management quality: evidence from public hospitals. *Review of Economic Studies* 82(2):457–89.

Brekke K, Siciliani L, Straume O. 2011. Hospital competition and quality with regulated prices. *Scandinavian Journal of Economics*, 113, 444-469.

Brekke, K., Gravelle, H., Siciliani, L., Straume, O. Patient choice, mobility and competition among health care providers. In Montefiori, M., Levaggi, R. (eds.), *Health Care Provision and Patient Mobility*, Springer, 2014; pp. 1-27

Brekke K, Holmas T, Monstad K, Straume O. 2017. Competition and physician behaviour: does the competitive environment affect the propensity to issue sickness certificates? Norwegian School of Economics, SAM 03, 2017.

Capps C, Dranove D, Ody C. 2017. Physician practice consolidation driven by small acquisitions, antitrust agencies have few tools to intervene. *Health Affairs* 36(9):1556–64.

Clemens J, Gottlieb J. 2017. In the shadow of a giant: Medicare's influence on private physician payments. *Journal of Political Economy* 125 (1):1–39.

Cooper Z, Gibbons S, Jones S, McGuire, A. 2011. Does hospital competition save lives? Evidence from the English patient choice reforms. *Economic Journal*, 121, F228–F260.

Department of Health. *Equitable Access to Primary Medical Care Services*. 2007. http://webarchive.nationalarchives.gov.uk/+/www.dh.gov.uk/en/Aboutus/Procurementandproposals/Procurement/ProcurementatPCTs/index.htm.

Dietrichson J, Ellegard L, Kjellsson G. 2016. Effects of increased competition on quality of primary care in Sweden. Lund Unversity Department of Economics Working Paper 2016:36

Doran T, Fullwood C, Gravelle H, Reeves D, Kontopantelis E, Hiroeh U, Roland M. 2006. Pay-for-performance programs in family practices in the United Kingdom. *New England Journal of Medicine,* 355, 375 – 384.

Fan Y. 2013. Ownership consolidation and product characteristics: A study of the US daily newspaper market. *American Economic Review*, 103(5): 1598–1628.

Fulton B. 2017. Health care market concentration trends in the United States: evidence and policy responses. *Health Affairs*, 36, 9, 1530-1538.

Gaynor M, Town R. 2012. Competition in health care markets. In *Handbook of Health Economics*, Vol. 2, ed. by M. Pauly, T. Mcguire, and P. Barros. Amsterdam: Elsevier, 499–637.

Gaynor M, Propper C, Seiler S. 2016. Free to choose: reform, choice and consideration sets in the English National Health Service. *American Economic Review* 166 (11) 3521-57.

Gaynor M, Moreno-Serra R, Propper C. 2013. Death by market power: reform, competition and patient outcomes in the National Health Service. *American Economic Journal: Economic Policy*, vol. 5, pp.134-166.

Gibbons S, Machin S. 2003. Valuing English primary schools, *Journal of Urban Economics* 53: 197-219

Gillam S, Siriwardena A, Steel N. 2012. Pay-for-performance in the United Kingdom: impact of the Quality and Outcomes Framework – a systematic review. *Annals of Family Medicine*, 10, 461-468.

Glied S, Altman S. 2017. Beyond antitrust: health care and health insurance market trends and the future of competition. *Health Affairs* 36:1572-1577

Gravelle H, Moscelli G, Santos R, Siciliani L. 2014. The effects of market structure and patient choice on mortality for AMI, hip fracture, and stroke patients. University of York, CHE RP 106.

Gravelle H, Scott A, Sivey P, Yong Y. 2016. Competition, prices and quality in the market for physician consultations. *Journal of Industrial Economics*, 65, 1, 135-169.

Gravelle H, Sutton M, Ma A. 2010. Doctor behaviour under a pay for performance contract: treating, cheating and case finding? *The Economic Journal*, 120(542), F129-F156.

Guthrie B, Tang J. 2016. What did we learn from 12 years of QOF? *Scottish School of Primary Care Literature Review.* http://www.sspc.ac.uk/media/media_486342_en.pdf

Hakin B. 2011. Equitable Access Programme: Primary Medical Care Services (letter). 2011 03/02/2011. https://www.gov.uk/government/uploads/system/uploads/attachment _data /file /215793/dh_123926.pdf

Harrison M, Dusheiko M, Sutton M, Gravelle H, Doran T, Roland M. 2014. Effect of a national primary care pay for performance scheme on emergency hospital admissions for ambulatory care sensitive conditions: controlled longitudinal study. *British Medical Journal*, 349:6423

Hayes, L., White, M., McNally, R., Unwin, N., Tran, A., Bhopal, R. 2017. Do cardiometabolic, behavioural and socioeconomic factors explain the 'healthy migrant effect' in the UK? *Journal of Epidemiology and Community Health*, 71, 863-869.

Kessler D, McClellan M. 2000. Is hospital competition socially wasteful? *The Quarterly Journal of Economics*. 115, 577-615.

Kontopantelis E, Springate D, Ashworth M, Webb R, Buchan I, Doran T. 2015. Investigating the relationship between quality of primary care and premature mortality in England: a spatial whole-population study. *British Medical Journal*, doi: 10.1136/bmj.h904 350:h904

Langdown C, Peckham S. 2014. The use of financial incentives to help improve health outcomes: is the quality and outcomes framework fit for purpose? A systematic review. *Journal of Public Health*, 36, 2, 251-258.

Matsa D. 2011. Competition and Product Quality in the Supermarket Industry. *Quarterly Journal of Economics*, 126, 1539–1591

Mays N, Tan S, Eastmure E, Erens B, Lagarde M, Wright M. 2014. Potential impact of removing general practice boundaries in England: a policy analysis. *Health Policy*, 118, 273-278.

Mazzeo J. 2003. Product choice and oligopoly market structure. *RAND Journal of Economics*, 33 (2): 221–42.

McGuire T. 2000. Physician agency. In A. Culyer and J. Newhouse (eds). *Handbook of Health Economics*, Volume 1A. North-Holland. Amsterdam.

Moscelli, G., Gravelle, H., Santos, R., Siciliani, L. The heterogeneous effects of market structure and patient choice on mortality for AMI, hip fracture, and stroke patients. *Social Science and Medicine*, 216, 2018, 50-58.

Munro J, Sampson F, Pickin M, Nicholl J. 2002. Patient de-registration from GP lists: and professional and patient perspectives. Medical Care Research Unit, University of Sheffield. Final report to the Department of Health. http://www.shef.ac.uk/scharr/sections/hsr/mcru/pastreports

OECD. 2012. *Competition in Hospital Services*, OECD Policy Roundtables, Directorate for Financial and Enterprise Affairs Competition Committee; available at www.oecd.org/daf/competition/50527122.pdf

Pike C. 2010. An empirical analysis of the effects of GP competition. *Co-operation and Competition Panel, Working Paper Series*, Volume 1, No. 2

Rebitzer, J., Taylor, L. 2011. Extrinsic rewards and intrinsic motives: standard and behavioural approaches to agency and labor markets. In Ashenfelter, O., Card, D. (eds.), *Handbook of Labor Economics*, Vol 4a. Elsevier

Roland M. 2004. Linking physician pay to quality of care: a major experiment in the UK. *New England Journal of Medicine*, vol. 351, pp. 1448–1454.

Ryan A, Krinsky S, Kontopantelis E, Doran T. 2016. Long-term evidence for the effect of pay-for-performance in primary care on mortality in the UK: a population study. *Lancet,* 388, 268-274.

Santos R, Gravelle H, Propper C. 2017. Does quality affect patients' choice of doctor? Evidence from the UK. *Economic Journal*, 2017, 127, 445-494 DOI: 10.1111/ecoj.12282,

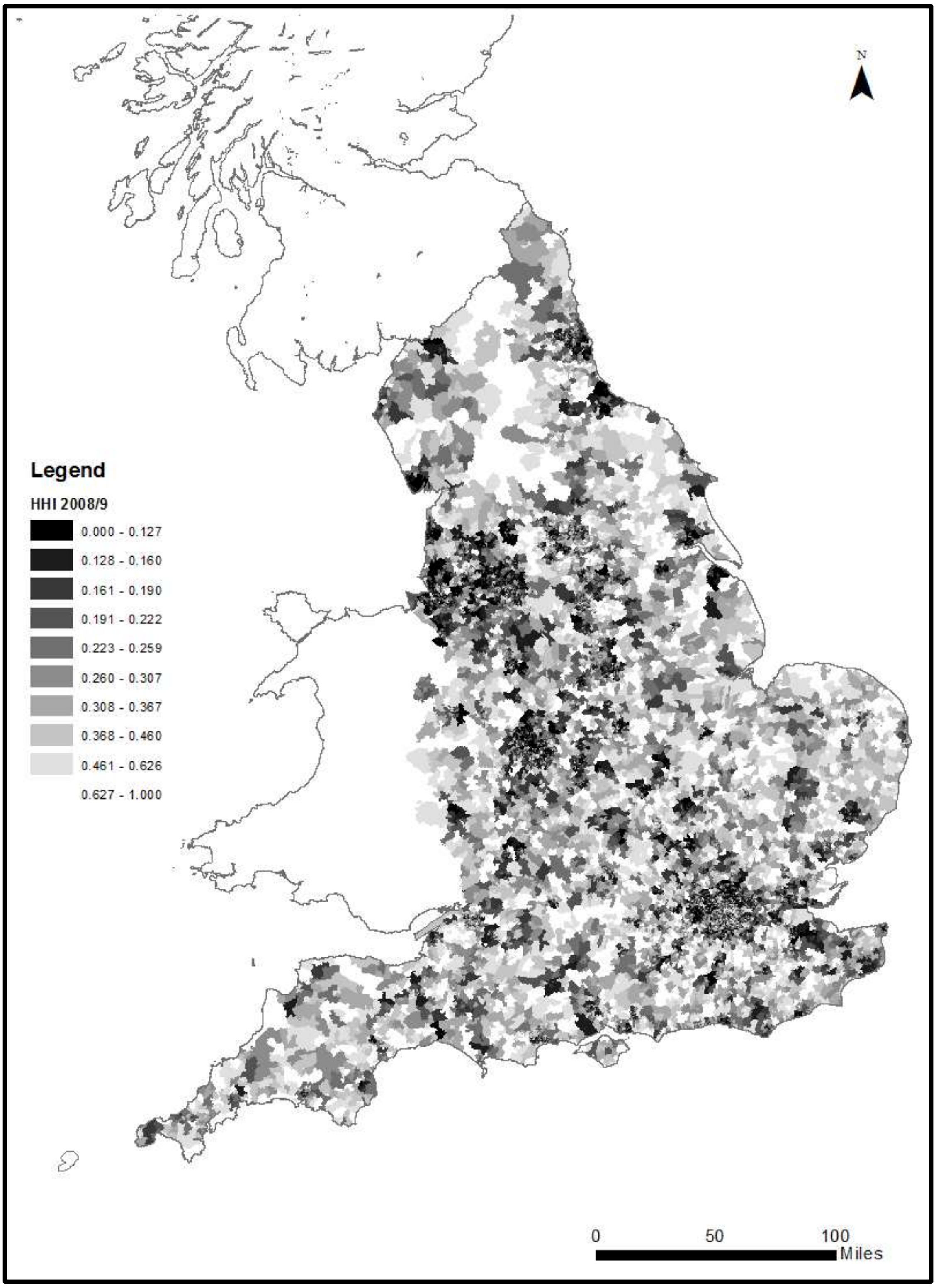
Schaumans C. 2015. Prescribing behaviour of general practitioners: competition matters. *Health Policy* 119 (4): 456–463.

Scott A, Sivey P, Ait Ouakrim D, Willenberg L, Naccarella L, Furler J, Young D. 2011. The effect of financial incentives on the quality of health care provided by primary care physicians. *Cochrane Library,* Issue 9.

Siciliani, L., Chalkley, M., Gravelle, H. Policies towards hospital and GP competition in five European countries. *Health Affairs*. 2017, 121, 103-110. DOI: 10.1016 /j.healthpol.2016.11.011

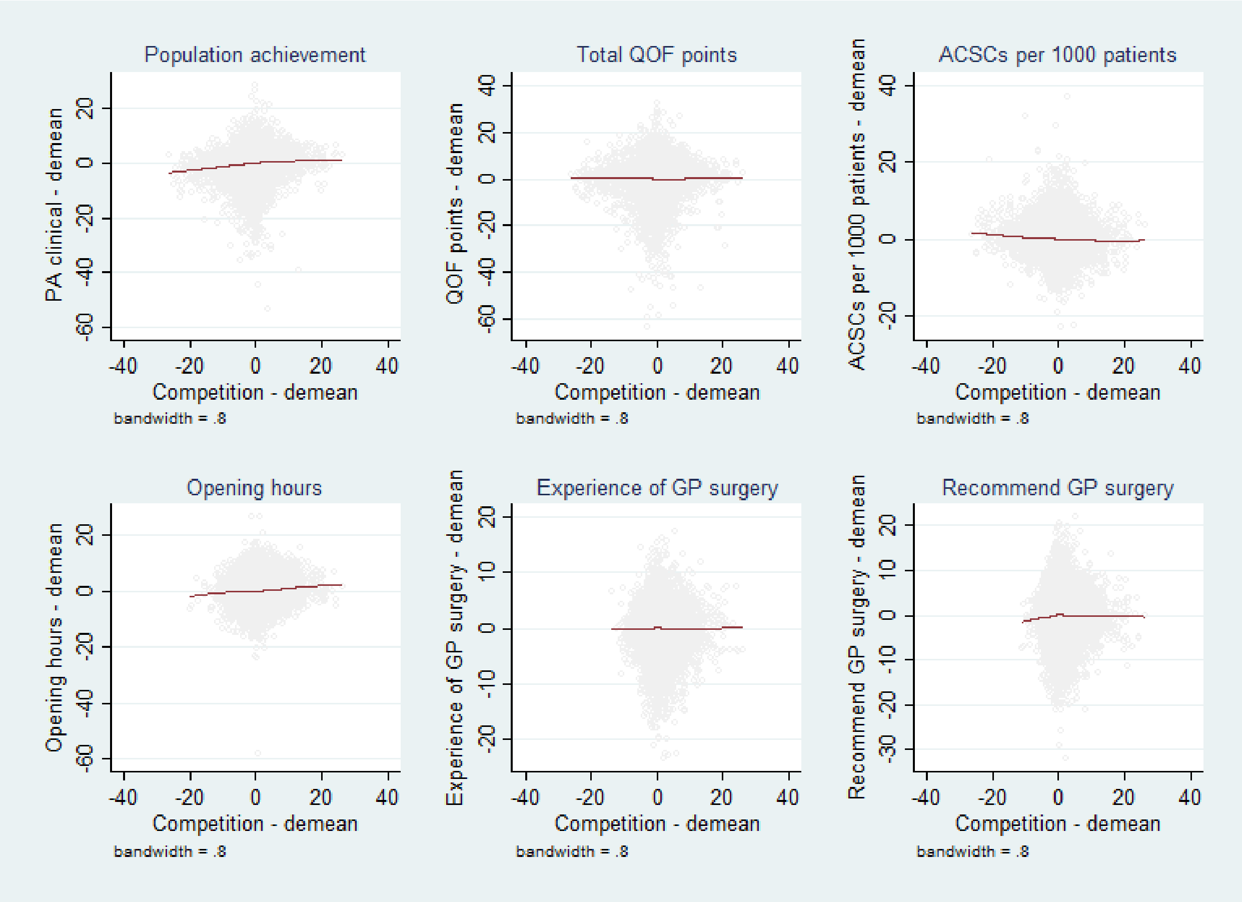
Sun E, Baker L C. 2015. Concentration in orthopedic markets was associated with a 7 percent increase in physician fees for total knee replacements. *Health Affairs* 34(6):916–21.

Figure 1: Family doctor market structure, England 2008



Notes: HHI is sum of squared shares of Lower Super Output Area populations registered at each general practice in England. LSOAs have mean populations of 1500. Shades are deciles of HHI distribution

Figure 2: Demeaned quality vs demeaned competition



Notes: Years: plots use full set of years for each quality measure. Demeaned quality: practice *g* quality in year *t* minus mean practice *g* quality over available years. Demeaned competition: practice *g* competition (number of FTE GPs in rival practices within 2km) in year minus mean practice *g* competition for same year as quality measure.

Table 1. Quality and competition measures: summary statistics

	Years		Mean	SD	Min	Max	Obs
Quality							
PA clinical	2005-12	Overall	79.13	4.93	5.90	97.33	63968
		Between		4.52	6.06	95.80	8329
		Within		2.81			$\bar{T}$:7.68
QOF points (% of maximum)	2005-12	Overall	95.90	5.39	11.84	100	63970
		Between		4.91	11.84	100	8329
		Within		3.52			$\bar{T}$:7.68
ACSC admissions per 1000 patients	2005-12	Overall	12.43	4.97	0	69.54	64000
		Between		4.32	0	35.88	8348
		Within		2.57			$\bar{T}$:7.67
% satisfied with opening hours	2006-12	Overall	82.48	6.72	0	100	55913
		Between		5.80	47.96	98.89	8279
		Within		3.51			$\bar{T}$:6.75
% satisfied with care	2008-12	Overall	90.14	6.60	40.16	100	39684
		Between		6.02	57.33	100	8103
		Within		2.79			$\bar{T}$:4.90
% would recommend practice	2009-12	Overall	82.77	10.62	23	100	31555
		Between		10.01	34.28	100	8024
		Within		3.76			$\bar{T}$:3.93
Competition							
FTE GPs in practices within 2km	2005-12	Overall	25.46	24.52	0.00	153.43	64676
		Between		24.46	0.00	146.49	8351
		Within		2.61			$\bar{T}$: 7.74

Notes: $\bar{T}$ = average number of years of observations per practice. PA: population achievement; QOF: Quality and Outcomes Framework; ACSC: ambulatory care sensitive condition; FTE: full time equivalent. $\bar{T}$: mean observations per practice.

Table 2: Competition and quality

	Covariates						Quality measure					
	Practice				Local		(1) PA clinical	(2) QOF points	(3) ACSCs	(4) Open hrs sat	(5) Care sat	(6) Recommend
	FEs	Demog	Morbidity & SES	Pop Density	Demog	Morbidity & SES	2005-12	2005-12	2005-12	2006-12	2008-12	2009-12
Panel A	N	N	N	N	N	N	-0.021***	-0.039***	-0.017***	-0.044***	-0.082***	-0.121***
							[0.002]	[0.002]	[0.002]	[0.003]	[0.003]	[0.005]
R^2							0.028	0.062	0.009	0.048	0.110	0.094
Panel B	Y	N	N	N	N	N	0.057***	0.027**	-0.019**	0.072***	0.061***	0.063***
							[0.008]	[0.009]	[0.006]	[0.010]	[0.010]	[0.015]
Within R^2							0.044	0.076	0.006	0.080	0.078	0.103
Panel C	Y	Y	Y	Y	N	N	0.025**	0.016	-0.007	0.046***	0.049***	0.054***
							[0.008]	[0.009]	[0.006]	[0.009]	[0.010]	[0.015]
Within R^2							0.0889	0.111	0.0469	0.0902	0.0925	0.117
Panel D	Y	N	N	Y	Y	Y	0.035***	0.022*	-0.005	0.054***	0.055***	0.054***
							[0.008]	[0.010]	[0.006]	[0.009]	[0.010]	[0.015]
Within R^2							0.051	0.078	0.010	0.087	0.080	0.105
Obs							63,968	63,970	64,000	55,913	39,684	31,555
Practices							8,329	8,329	8,348	8,279	8,103	8,024

Notes. Competition measure: *N rival GPs*: number of FTE GPs in other practices with at least one branch within 2km of a branch of the practice. All models include year dummies. *Practice covariates*: characteristics of patients on practice list or mean of characteristics of LSOAs weighted by the proportion of LSOA population on the practice list. *Local covariates*: demography and SES are means of characteristics of populations of MSOAs in which practice has a branch; morbidity is list size weighted mean of morbidity of practice and five nearest rivals. Square brackets: robust SEs clustered at practice level. *** p<0.001, ** p<0.01, * p<0.05

Table 3: Competition and quality within homogeneous Parliamentary Constituencies

	(1) PA clinical 2005-12	(2) QOF points 2005-12	(3) ACSC 2005-12	(4) Open hrs sat 2006-12	(5) Care sat 2008-12	(6) Recommend 2009-12
N rival GPs	0.037**	0.022	-0.033***	0.066***	0.053***	0.061**
	[0.011]	[0.015]	[0.009]	[0.014]	[0.016]	[0.023]
Within R^2	0.0834	0.0694	0.0265	0.0682	0.0564	0.0747
Obs	15,769	15,771	15,810	13,842	9,773	7,754
Practices	2,081	2,081	2,087	2,072	2,013	1,985

Notes. Competition measure: number of FTE GPs in other practices with at least one branch within 2km of a branch of the practice. Sample: practices in 107 Parliamentary Constituencies in the bottom quintile of the coefficient of variation of the LSOA level Index of Multiple Deprivation. All models include practice fixed effects, year effects, local population characteristics (population density, age/gender proportions, morbidity, SES). Square brackets: robust SEs clustered at practice level. *** p<0.001, ** p<0.01, * p<0.05.

Table 4: Alternative competition radii

	(1) PA clinical 2005-12	(2) QOF points 2005-12	(3) ACSC 2005-12	(4) Open hrs sat 2006-12	(5) Care sat 2008-12	(6) Recommend 2009-12
Panel A. Number GPs in rival practices within 500m						
N rival GPs	0.006	-0.011	0.021	0.063*	0.063*	0.089
	[0.024]	[0.029]	[0.020]	[0.029]	[0.030]	[0.046]
Within R^2	0.0505	0.0782	0.0103	0.0862	0.0784	0.105
Panel B. Number GPs in rival practices within 1km						
N rival GPs	0.042**	0.011	-0.009	0.096***	0.088***	0.076**
	[0.015]	[0.019]	[0.012]	[0.017]	[0.018]	[0.028]
Within R^2	0.0508	0.0782	0.0103	0.0870	0.0792	0.105
Panel C. Number GPs in rival practices within 2km						
N rival GPs	0.035***	0.022*	-0.005	0.054***	0.055***	0.054***
	[0.008]	[0.010]	[0.006]	[0.009]	[0.010]	[0.015]
Within R^2	0.0513	0.0784	0.0103	0.0872	0.0796	0.105
Panel D. Number GPs in rival practices within 3km						
N rival GPs	0.027***	0.012	-0.003	0.038***	0.036***	0.036***
	[0.005]	[0.006]	[0.004]	[0.006]	[0.007]	[0.011]
Within R^2	0.0517	0.0783	0.0103	0.0873	0.0796	0.105
Panel E. Number GPs in rival practices within 5km						
N rival GPs	0.018***	0.005	-0.000	0.024***	0.022***	0.024***
	[0.003]	[0.003]	[0.002]	[0.003]	[0.004]	[0.006]
Within R^2	0.0524	0.0783	0.0103	0.0876	0.0799	0.105
Obs	63,968	63,970	64,000	55,913	39,684	31,555
Practices	8,329	8,329	8,348	8,279	8,103	8,024

Notes: Competition measures: FTE GPs in other practices with at least one branch within 500 metres (panel A), 1km (panel B), 2 km (panel C), 3km (panel D) and 5km (panel E) of a branch of the practice. All models include practice fixed effects, year effects, local population characteristics (population density, age/gender proportions, morbidity, SES). Square brackets: robust SEs clustered at practice level. *** p<0.001, ** p<0.01, * p<0.05.

Table 5. Robustness: market and competition definitions

	PA clinical 2006-12	QOF points 2006-12	ACSC 2006-12	Open hrs sat 2006-12	Care sat 2008-12	Recommend 2009-12
Panel A:PCT level errors						
N rival GPs	0.034***	0.021	-0.003	0.052***	0.053***	0.051**
	[0.010]	[0.013]	[0.017]	[0.014]	[0.013]	[0.017]
Within R^2	0.0504	0.0806	0.0101	0.0873	0.0799	0.105
Obs	63,438	63,440	63,556	55,475	39,390	31,325
Practices	8,215	8,215	8,216	8,203	8,039	7,962
*Panel B:PCT*year effects*						
N rival GPs	0.000	0.010	0.003	0.029**	0.036**	0.027
	[0.011]	[0.013]	[0.007]	[0.011]	[0.012]	[0.018]
Within R^2	0.109	0.132	0.166	0.141	0.111	0.132
Obs	63,438	63,440	63,556	55,475	39,390	31,325
Panel C:PCT level model						
N rival GPs	0.033	0.017	-0.027	0.064	0.038	-0.029
	[0.031]	[0.035]	[0.043]	[0.041]	[0.028]	[0.047]
Within R^2	0.248	0.502	0.134	0.156	0.710	0.796
Obs	1,216	1,216	1,216	1,064	608	456
Panel D:lagged competition						
N rival GPs t−1.	0.035***	0.022*	-0.009	0.020*	0.055***	0.082***
	[0.008]	[0.011]	[0.006]	[0.009]	[0.011]	[0.015]
Within R^2	0.0380	0.0870	0.00762	0.0863	0.0795	0.106
Obs	55,672	55,674	55,657	55,890	39,677	31,549
Panel E:Rival practices and rival GPs						
N rival GPs	0.035***	0.022*	-0.004	0.054***	0.055***	0.052***
	[0.008]	[0.010]	[0.006]	[0.009]	[0.010]	[0.015]
N rival practices	-0.123**	-0.084	0.169***	0.040	0.021	0.079
	[0.047]	[0.055]	[0.035]	[0.049]	[0.056]	[0.086]
Within R^2	0.0517	0.0785	0.0112	0.0872	0.0796	0.105
Obs	63,968	63,970	64,000	55,913	39,684	31,555

Notes: Fixed effects included in all models. Covariates in all models are at local area level. In Panel C we take list size weighted means. Square brackets: robust SEs clustered at practice level (PCT level in Panel A). *** p<0.001, ** p<0.01, * p<0.05

Table 6. Robustness: GP composition

	PA clinical	QOF points	ACSC	Open hrs sat	Care sat	Recommend
	2006-12	2006-12	2006-12	2006-12	2008-12	2009-12
Panel A –controlling for N own GPs						
N rival GPs	0.034***	0.019*	-0.002	0.054***	0.052***	0.049**
	[0.008]	[0.010]	[0.006]	[0.009]	[0.010]	[0.015]
Within R^2	0.0505	0.0816	0.0109	0.0874	0.0822	0.109
Obs	63,572	63,574	63,847	55,461	39,455	31,437
Practices	8,314	8,314	8,327	8,259	8,091	8,011
Panel B – controlling for N own GPs and own GP characteristics						
N rival GPs	0.033***	0.019*	-0.003	0.052***	0.050***	0.047**
	[0.008]	[0.009]	[0.006]	[0.009]	[0.010]	[0.015]
Within R^2	0.0551	0.0871	0.0118	0.0887	0.0879	0.112
Obs	63,532	63,534	63,795	55,399	39,393	31,377
Practices	8,314	8,314	8,326	8,259	8,086	8,003
Panel C – controlling for N rivals GPs and rival GP characteristics						
N rival GPs	0.035***	0.024*	-0.000	0.053***	0.058***	0.054***
	[0.008]	[0.010]	[0.006]	[0.010]	[0.010]	[0.016]
Within R^2	0.0516	0.0785	0.0111	0.0877	0.0800	0.105
Obs	63,951	63,953	63,978	55,903	39,683	31,555
Practices	8,316	8,316	8,326	8,272	8,102	8,024
Panel D – controlling for N own GPs and characteristics of own and rival GPs						
N rival GPs	0.033***	0.021*	0.001	0.051***	0.054***	0.049**
	[0.008]	[0.010]	[0.006]	[0.010]	[0.010]	[0.016]
Within R^2	0.0554	0.0871	0.0124	0.0893	0.0883	0.112
Obs	63,531	63,533	63,794	55,399	39,393	31,377
Practices	8,313	8,313	8,325	8,259	8,086	8,003

Notes. Competition measure: *N rival GPs*: number of FTE GPs in other practices with at least one branch within 2km of a branch of the practice. *N own GPs*: number of FTE GPs in own practice. GP characteristics: % female, % salaried, % qualified outside Europe, % aged 40-60, % aged over 60. All models include practice fixed effects, year effects, local population characteristics (population density, age/gender proportions, morbidity, SES). Square brackets: robust SEs clustered at practice level. *** p<0.001, ** p<0.01, * p<0.05

Table 7: Long difference estimates of effect of competition

	ΔPA clinical	**Δ**QOF points	**Δ**ACSCs	**Δ**Open hours sat
ΔN rival GPs	0.087***	0.071***	-0.074***	0.071***
	[0.016]	[0.019]	[0.015]	[0.018]
R^2	0.028	0.011	0.029	0.042
Obs	7,845	7,845	7,845	7,842

Notes: ΔN rival GPs: average FTE GPs in practices within 2km 2009/10-2011/12 minus average FTE GPs in practices within 1km 2005/6-2007/8. ΔQuality, Δcovariates: average quality and local area covariates 2009/10-2011/12 *minus* average quality and local area covariates 2005/6-2007/8. Square brackets: robust SEs. *** p<0.001, ** p<0.01, * p<0.05.

Table 8: Exploiting the EAPMC policy (Long difference estimates)

	ΔPA clinical	ΔQOF points	ΔACSCs	ΔOpen hours sat
Panel A: All practices				
EAPMC	0.583***	0.430**	0.108	0.190
	[0.116]	[0.132]	[0.102]	[0.130]
R^2	0.026	0.009	0.022	0.040
Obs	7,792	7,792	7,793	7,789
Panel B: practices within 2k km of EAPMC PCT boundary				
EAPMC	0.497*	0.416	0.182	-0.338
	[0.248]	[0.303]	[0.207]	[0.284]
Within R^2	0.040	0.032	0.050	0.090
Obs	1,125	1,125	1,126	1,125

Notes: Model: ΔQuality regressed on constant, EAPMC, Δcovariates. ΔQuality and Δcovariates: average quality and local area covariates 2009/10-2011/12 *minus* average quality and local area covariates 2005/6-2007/8. EAPMC: indicator for practice in an EAPMC PCT. Square brackets: robust SEs. *** $p<0.001$, ** $p<0.01$, * $p<0.05$.

Table 9: Heterogeneity with respect to initial competition

	(1)	(2)	(3)	(4)	(5)	(6)
	PA clinical	QOF points	ACSC	Open hrs sat	Care sat	Recommend
	2005-12	2005-12	2005-12	2006-12	2008-12	2009-12
Panel A: interaction with bottom quartile of initial competition						
N rival GPs	0.036***	0.022*	-0.005	0.053***	0.058***	0.056***
	[0.008]	[0.010]	[0.006]	[0.009]	[0.010]	[0.015]
Q1*N rival GPs	-0.042	-0.011	0.058	0.045	-0.156*	-0.071
	[0.049]	[0.050]	[0.046]	[0.063]	[0.077]	[0.099]
Within R^2	0.051	0.079	0.010	0.087	0.80	0.106
Panel B: interaction with top quartile of initial competition						
N rival GPs	0.029*	0.042**	-0.002	0.006	0.026	0.011
	[0.013]	[0.015]	[0.011]	[0.014]	[0.015]	[0.025]
Q4*N rival GPs	0.009	-0.029	-0.003	0.072***	0.043*	0.066*
	[0.016]	[0.019]	[0.013]	[0.019]	[0.019]	[0.031]
Within R^2	0.051	0.079	0.010	0.088	0.80	0.106
Obs	63,879	63,879	63,881	63,906	55,822	39,622
Practices	8,307	8,307	8,307	8,312	8,261	8,087

Notes: *N rival GPs*: number of FTE GPs in other practices with at least one branch within 2 km of a branch of the practice. Q1 (Q4): practice was in lowest (highest) competition quartile of average 2005/6 and 2006/7 competition. All models include practice fixed effects, year effects, local population characteristics (population density, age/gender proportions, morbidity, SES). Square brackets: robust SEs clustered at practice level. *** p<0.001, ** p<0.01, * p<0.05.

Appendix

Figure A1. EAPMC PCTs and all GP surgeries, England 2010

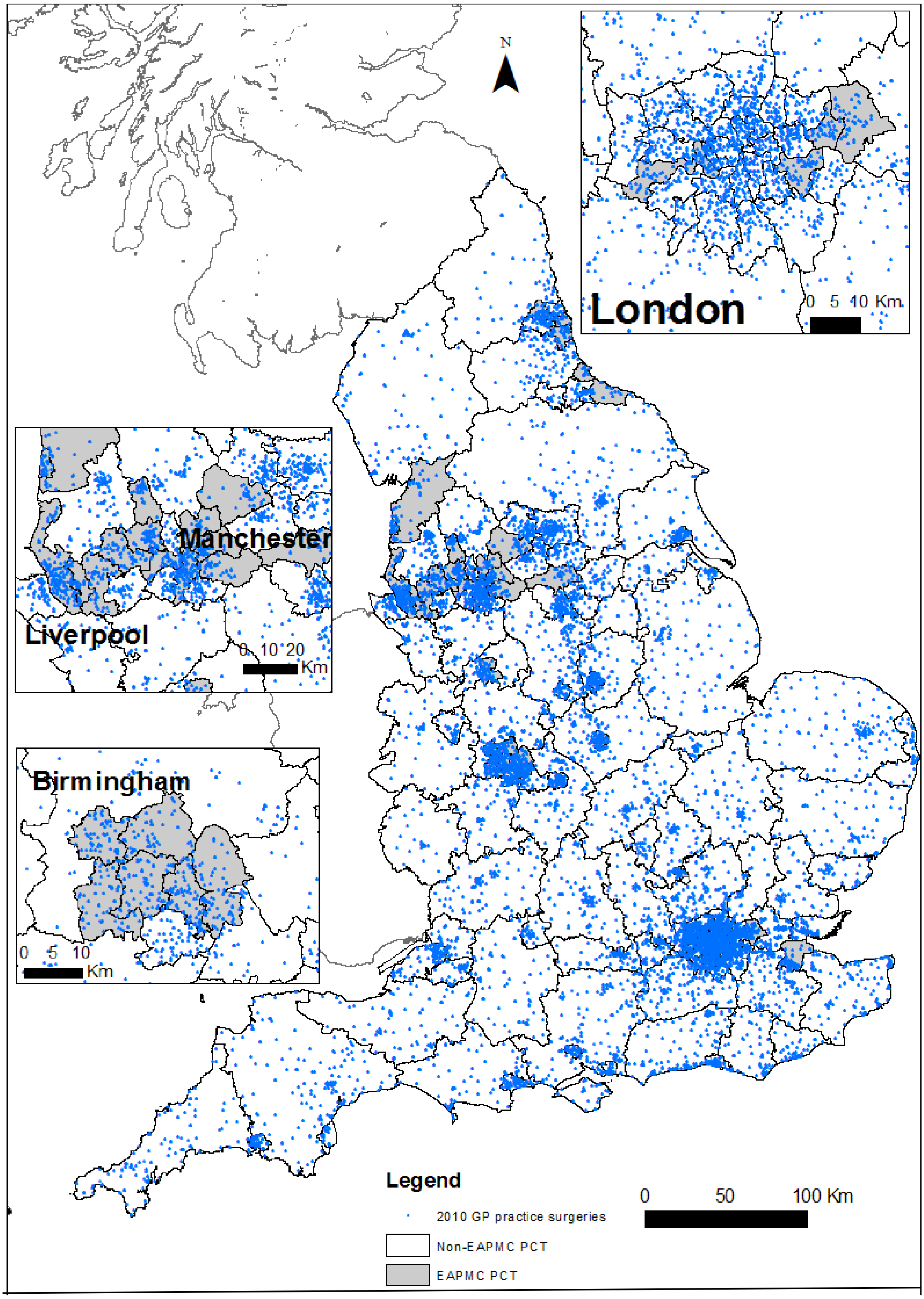
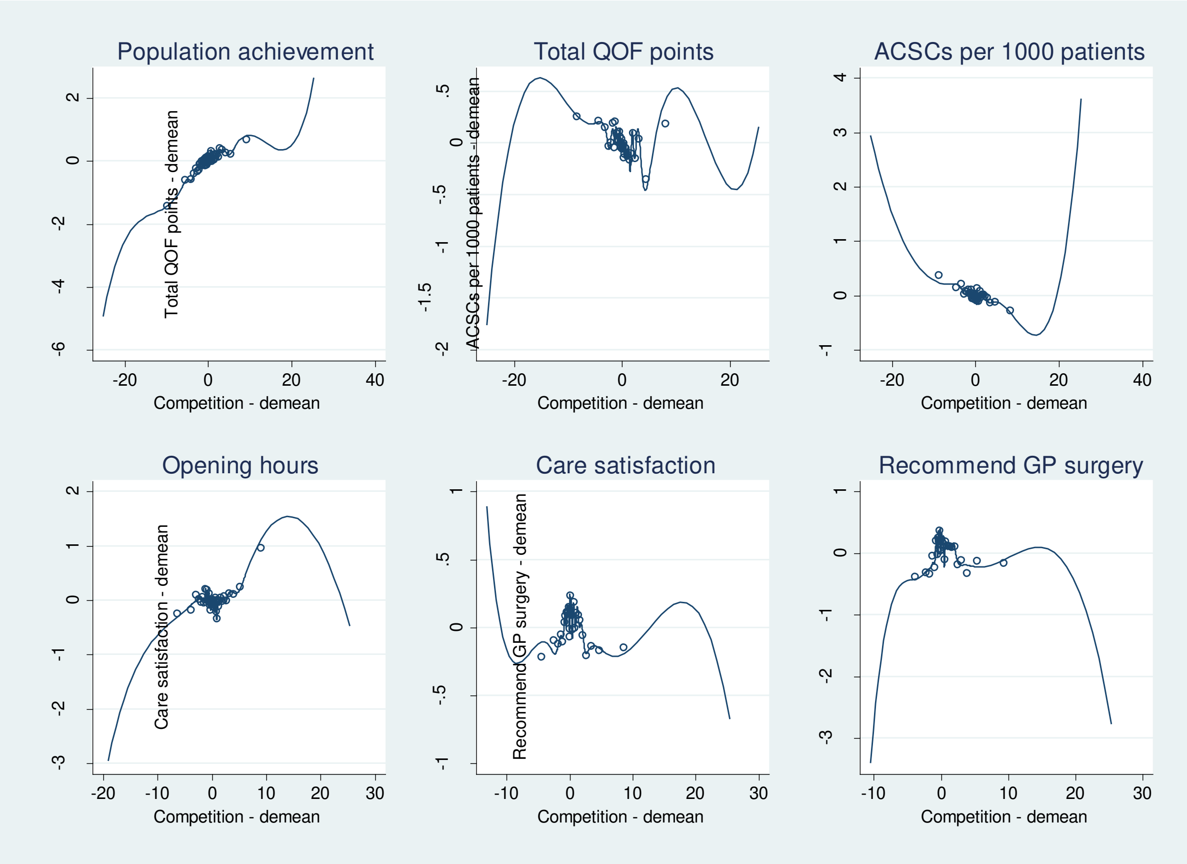


Figure A2: Demeaned quality vs demeaned competition: scatter bin plots



Notes: Years: plots use full set of years for each quality measure. Demeaned quality: practice g quality in year t minus mean practice g quality over available years. Demeaned competition: practice g competition (number of FTE GPs in rival practices within 2km) in year minus mean practice g competition for same year as quality measure. 2009 to 2012. Plots produced by *binsreg* with optimally chosen number of bins and cubic spline estimate of regression function over bins.

Table A1: Covariate summary statistics (2005/6-2012/13)

		Mean	SD	Min	Max
Local area covariates					
Population Density (000s per sq km)	Overall	3.72	3.65	0.01	25.16
	Between		3.65	0.01	24.52
	Within		0.23		
% of males 0-15	Overall	9.78	2.02	1.14	19.39
	Between		1.99	1.64	19.05
	Within		0.37		
% of males 16-24	Overall	6.20	2.79	2.45	35.61
	Between		2.75	2.73	34.35
	Within		0.43		
% of males 50-64	Overall	8.51	1.93	1.23	14.50
	Between		1.92	1.43	13.96
	Within		0.28		
% of males at least 65	Overall	6.79	2.35	0.80	20.79
	Between		2.31	1.07	18.80
	Within		0.41		
% of females 0-15	Overall	9.33	1.94	0.92	19.10
	Between		1.92	1.50	18.78
	Within		0.35		
% of females 16-24	Overall	6.13	2.87	2.12	42.59
	Between		2.83	2.27	39.24
	Within		0.43		
% of females 25-49	Overall	17.82	2.74	4.53	32.62
	Between		2.72	5.02	31.09
	Within		0.43		
% of females 50-64	Overall	6.59	1.95	0.95	14.22
	Between		1.47	1.17	10.77
	Within		1.29		
% of females at least 65	Overall	10.91	3.83	0.69	33.16
	Between		3.64	1.35	31.52
	Within		1.19		
Income IMD score rank	Overall	14.45	7.73	0.06	32.44
	Between		7.70	0.15	32.38
	Within		0.66		
Crime IMD score rank	Overall	14.34	7.82	0.04	32.33
	Between		7.67	0.23	31.95
	Within		1.52		
Living IMD score rank	Overall	13.96	7.95	0.07	32.54
	Between		7.87	0.12	32.27
	Within		1.25		
Education IMD score rank	Overall	15.28	8.09	0.06	32.55
	Between		8.06	0.07	32.37
	Within		0.79		

		Mean	SD	Min	Max
% of residents on IBDA	Overall	5.15	2.44	0.28	17.76
	Between		2.41	0.40	17.36
	Within		0.31		
Practice plus 5 nearest rivals					
Nursing home patients ('000s)	Overall	5.21	3.40	0.00	73.44
	Between		1.84	0.00	14.79
	Within		2.87		
CHD prevalence (%)	Overall	3.51	1.00	0.32	11.28
	Between		0.69	1.28	6.31
	Within		0.72		
Stroke prevalence (%)	Overall	1.66	0.49	0.10	5.73
	Between		0.34	0.65	2.75
	Within		0.36		
Hypertension prevalence (%)	Overall	13.19	2.55	1.81	43.95
	Between		1.64	6.37	21.94
	Within		1.95		
Diabetes prevalence (%)	Overall	4.28	0.97	0.94	13.61
	Between		0.65	2.08	7.42
	Within		0.72		
Epilepsy prevalence (%)	Overall	0.61	0.14	0.06	1.59
	Between		0.10	0.28	1.19
	Within		0.10		
COPD prevalence (%)	Overall	1.59	0.62	0.06	7.24
	Between		0.43	0.58	4.44
	Within		0.45		
Hypothyroidism prevalence (%)	Overall	2.84	0.79	0.18	7.29
	Between		0.54	0.91	6.06
	Within		0.57		
Cancer prevalence (%)	Overall	1.31	0.55	0.10	4.29
	Between		0.45	0.35	2.79
	Within		0.31		
Mental illness prevalence (%)	Overall	0.77	0.25	0.14	2.50
	Between		0.16	0.29	1.61
	Within		0.20		
Asthma prevalence (%)	Overall	5.90	0.89	0.66	13.50
	Between		0.61	3.27	9.63
	Within		0.65		

*Note***.** IMD rank scores are IMD rank divided by the number of LSOAs (32,482). Observations: 63,968 practice-year observations on 8329 practices over an average of 7.68 years.

Table A2: Quality and competition measures: correlations between demeaned variables (2009/12-2012/13)

	PA clinical	QOF points	ACSCs	Open hrs satisfact	Overall satisfact	Recommend	N rival GPs
QOF points	0.5943*	1					
ACSCs per 1000 patients	-0.0115*	-0.0308*	1				
Open hrs satisfaction	0.0621*	0.1244*	0.0027	1			
Overall satisfaction	0.0353*	-0.0450*	0.0398*	0.3937*	1		
Recommend	0.0180*	-0.0693*	0.0424*	0.2909*	0.6858*	1	
N rival GPs	0.0473*	0.0306*	-0.0192*	0.0526*	0.0171*	-0.0018	1
N rival practices	-0.0284*	-0.0059	0.0413*	0.0001	0.0214*	0.0303*	-0.0383*

Notes. N rival GPs: number of full-time equivalent GPs in other practices with at least one branch within 2km of a branch of the practice. *N rival practices*: number of GP practices with at least one branch within 2km of a branch of the practice.

Table A3: Competition measures at different radii

		Number of GPs in rival practices within radius					Proportion patients choosing practices within this radius of their LSOA
Radius		Mean	SD	Min	Max	% with no rivals	Mean
500m	Overall	3.58	4.70	0	45.99	40.94%	0.125
	Between		4.67	0	37.67		
	Within		0.74				
1km	Overall	8.73	8.79	0	67.45	20.71%	0.359
	Between		8.74	0	57.46		
	Within		1.24				
2km	Overall	25.46	24.52	0	153.43	10.78%	0.681
	Between		24.46	0	146.49		
	Within		2.61				
3 km	Overall	49.42	49.62	0	298.91	7.86%	0.823
	Between		49.64	0	278.82		
	Within		4.37				
5km	Overall	116.24	126.01	0	677.77	4.04%	0.932
	Between		126.26	0	626.68		
	Within		9.07				

Notes: Statistics for FTE number of GPs in rival practices from 64,676 observations on 8351 practices, 2005-2012. Statistics for proportion of patients choosing a practice within different distances from the centroid of their LSOA are for April 2010 for patients resident in 2875 LSOAs in the East Midlands region

Table A4: Full results basic model (Table 2, Panel D)

	PA clinical 2005-12	QOF points 2005-12	ACSCs 2005-12	Open hrs sat 2006-12	Care sat 2008-12	Recommend 2009-12
N rival GPs 2km	0.035***	0.022*	-0.005	0.054***	0.055***	0.054***
	[0.008]	[0.010]	[0.006]	[0.009]	[0.010]	[0.015]
Population Density	0.265*	-0.219	-0.272***	0.954***	-0.072	0.037
	[0.119]	[0.148]	[0.081]	[0.170]	[0.194]	[0.312]
Males 0-15	0.045	-0.098	0.004	0.239**	-0.136	-0.220
	[0.073]	[0.084]	[0.053]	[0.086]	[0.100]	[0.175]
Males 16-24	-0.068	-0.130	0.031	0.141	0.002	0.071
	[0.062]	[0.070]	[0.045]	[0.074]	[0.083]	[0.134]
Males 50-64	0.182*	0.144	-0.176**	0.286**	-0.079	-0.336
	[0.089]	[0.102]	[0.064]	[0.108]	[0.117]	[0.203]
Males 65plus	-0.332***	-0.130	0.172*	0.292*	-0.087	-0.349
	[0.092]	[0.109]	[0.068]	[0.115]	[0.129]	[0.224]
Females 0-15	-0.117	-0.201*	0.105	0.034	-0.194	-0.339
	[0.074]	[0.089]	[0.056]	[0.092]	[0.107]	[0.187]
Females 16-24	0.100	0.099	0.040	0.156*	-0.121	-0.343*
	[0.066]	[0.078]	[0.047]	[0.079]	[0.092]	[0.162]
Females 25-49	-0.011	-0.120	0.126*	0.287**	-0.051	-0.308
	[0.083]	[0.100]	[0.058]	[0.097]	[0.107]	[0.180]
Females 50-64	0.112	-0.307**	0.181**	0.463***	-0.049	-0.067
	[0.081]	[0.097]	[0.057]	[0.098]	[0.104]	[0.179]
Females 65plus	-0.095	-0.116	0.112*	0.451***	-0.022	0.106
	[0.074]	[0.087]	[0.051]	[0.090]	[0.100]	[0.177]
Income IMD score rank	0.017	-0.045	-0.022	0.249***	0.074	0.743
	[0.028]	[0.034]	[0.019]	[0.036]	[0.040]	[0.560]
Crime IMD score rank	-0.019	0.009	-0.006	-0.070***	-0.030*	-0.063*
	[0.012]	[0.013]	[0.008]	[0.015]	[0.015]	[0.028]
Living IMD score rank	-0.009	0.006	0.015	-0.011	-0.035*	-0.041
	[0.014]	[0.017]	[0.011]	[0.018]	[0.017]	[0.031]
Education IMD score rank	0.169***	0.043	0.043**	-0.013	0.047	0.049
	[0.024]	[0.027]	[0.016]	[0.031]	[0.032]	[0.056]
% of residents on IBDA	-0.227*	-0.133	0.289***	-0.179	-0.256	-0.331
	[0.098]	[0.119]	[0.071]	[0.110]	[0.137]	[0.241]
Nursing Home patients	0.004	0.002	-0.002	-0.003	0.002	-0.002
	[0.005]	[0.006]	[0.005]	[0.007]	[0.007]	[0.011]
CHD Prevalence	0.065	0.037	0.003	0.012	0.067	-0.040
	[0.038]	[0.047]	[0.036]	[0.051]	[0.053]	[0.084]

Stroke Prevalence	-0.025	-0.085	0.107	-0.041	-0.072	0.115
	[0.076]	[0.094]	[0.074]	[0.102]	[0.104]	[0.167]
Hypertension Prev	-0.019	-0.036*	0.000	0.027	0.006	0.022
	[0.012]	[0.015]	[0.011]	[0.016]	[0.017]	[0.027]
Diabetes Prevalence	-0.012	0.030	-0.023	-0.011	0.022	0.092
	[0.024]	[0.029]	[0.022]	[0.032]	[0.032]	[0.050]
Epilepsy Prevalence	0.062	0.023	-0.069	0.058	-0.259	-0.155
	[0.175]	[0.214]	[0.167]	[0.235]	[0.238]	[0.381]
COPD Prevalence	-0.087	-0.025	-0.011	0.004	0.005	-0.010
	[0.045]	[0.054]	[0.040]	[0.057]	[0.057]	[0.093]
Hypo Prevalence	0.005	-0.006	-0.006	-0.025	-0.008	-0.076
	[0.033]	[0.041]	[0.031]	[0.044]	[0.046]	[0.071]
Cancer Prevalence	0.034	0.143	-0.023	-0.074	-0.087	-0.032
	[0.068]	[0.082]	[0.061]	[0.090]	[0.092]	[0.146]
Mental Illness Prevalence	0.047	-0.006	0.074	0.032	0.012	-0.029
	[0.069]	[0.087]	[0.062]	[0.091]	[0.089]	[0.145]
Asthma Prevalence	0.010	0.010	-0.019	-0.014	0.022	-0.001
	[0.021]	[0.026]	[0.020]	[0.028]	[0.029]	[0.046]
year2006	0.289***	-0.854***	-0.331***			
	[0.047]	[0.057]	[0.039]			
year2007	1.506***	0.365***	-0.606***	-1.825***		
	[0.060]	[0.066]	[0.045]	[0.049]		
year2008	1.595***	-1.098***	-0.408***	-2.669***		
	[0.070]	[0.078]	[0.054]	[0.068]		
year2009	0.942***	-2.586***	-0.547***	-2.193***	-0.451***	
	[0.083]	[0.095]	[0.063]	[0.081]	[0.041]	
year2010	1.337***	-1.883***	-0.301***	-3.097***	-0.744***	-0.310***
	[0.096]	[0.109]	[0.072]	[0.097]	[0.061]	[0.066]
year2011	1.228***	0.883***	-0.744***	-0.775***	-1.100***	-1.016***
	[0.145]	[0.179]	[0.119]	[0.184]	[0.180]	[0.246]
year2012	0.693***	0.058	-0.929***	-1.897***	-2.166***	-2.557***
	[0.151]	[0.190]	[0.125]	[0.190]	[0.185]	[0.251]
Constant	76.781***	105.534***	6.371*	55.909***	96.830***	90.675***
	[4.119]	[4.984]	[2.970]	[4.873]	[5.421]	[12.046]
Observations	63,968	63,970	64,000	55,913	39,684	31,555
Practices	8,329	8,329	8,348	8,279	8,103	8,024
Within R^2	0.0513	0.0784	0.0103	0.0872	0.0796	0.105

Notes. Competition measure: *N rival GPs*: number of full-time equivalent GPs in other practices with at least one branch within 2km of a branch of the practice. All models include practice fixed effects. Local area covariates. Square brackets: robust SEs clustered at practice level. *** p<0.001, ** p<0.01, * p<0.05

Table A5. Effect of EAPMC on competition (N GPs in rival practices)

	N rival GPs within 2km
EAPMC	1.096***
	[0.095]
R^2	0.018
Obs	7,793

After: Dependent variable: Mean 2009-11 N GPs in rival practices minus mean 2005-7 N GPs in rival practices. EAPMC: practice was in an EAPMC PCT.

Table A6: Comparison of EAPMC and non-EAPMC practices (average 2005-2007)

	All practices			Practices within 2km of EAPMC boundary		
	Non-EAPMC	EAPMC	t-stat for difference in means	Non-EAPMC	EAPMC	t-stat for difference in means
N rival GPs within 2km	23.98	27.34	11.73	34.56	27.67	-9.44
PA clinical	78.80	78.29	-5.51	78.98	78.13	-4.85
QOF points	96.73	95.42	-13.46	96.09	95.43	-3.36
ACSC	11.66	15.37	46.15	12.34	14.40	13.62
Open hrs sat	82.91	83.95	7.62	81.88	82.91	3.63
Population density	3.49	4.16	14.62	5.53	3.94	-13.83
Income IMD score rank	15.72	9.85	-55.99	13.38	10.81	-11.75
Crime IMD score rank	15.54	10.08	-55.94	12.38	10.43	-10.46
Living IMD score rank	14.80	10.53	-38.85	11.57	11.82	1.17
Education IMD rank score	16.77	10.19	-59.00	16.77	11.72	-21.40
IBDA (%)	4.40	6.64	58.60	4.90	5.97	15.31
Nursing Home patients (%)	5.15	5.39	4.67	5.20	5.29	0.79
CHD Prevalence (%)	3.48	3.61	8.81	3.45	3.56	3.88
Stroke Prevalence (%)	1.66	1.67	1.99	1.67	1.67	0.50
Hyper Prevalence (%)	13.25	13.06	-4.93	13.20	13.19	-0.05
Diabetes Prevalence (%)	4.34	4.08	-18.07	4.28	4.19	-2.98
Epilepsy Prevalence (%)	0.61	0.62	4.47	0.61	0.62	1.83
COPD Prevalence (%)	1.60	1.58	-1.41	1.58	1.60	0.84
Hypo Prevalence (%)	2.88	2.74	-11.59	2.89	2.81	-3.20
Cancer Prevalence (%)	1.36	1.15	-27.06	1.37	1.26	-7.18
Mental Illness Prevalence (%)	0.78	0.74	-11.85	0.79	0.76	-3.69
Asthma Prevalence (%)	5.89	5.92	2.27	5.83	5.88	2.17

Notes: Covariates measured at local area level. Number of observations for t tests: All practices - N rival GPs, covariates 24573; PA clinical 24406, QOF points 24407, ACSC 24403, Open Hrs sat 16085; Practices within 2km of EAPMC border – N rival GPs, covariates 3632, PA clinical, QOF points 3597, ACSC 3601, Op Hrs sat 2738.